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Table of Contents

VOL. 18 APRIL, 1935 No. 4

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The Water-Smoking Period and Its Control 113
By J. L. Carruthers

Titanium Compounds and Application Thereof in Vitreous Enamels 117
By C. J. Kinzie and J. A. Plunkett

Micro-Gas Analysis of Gas Trapped in Vitreous Enamels on Enameling Iron 123
By S. E. Freeman and V. W. Meloche

Constituents and Properties of "Radex" 125
By P. P. Budnikoff and B. J. Pines

The Guarded Radiation Plate Method for the Determination of Thermal Conductivity of Refractories at Elevated Temperatures 128
By C. A. Peterson

Ceramic Abstracts

85

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THE WATER-SMOKING PERIOD AND ITS CONTROL*

By J. L. Carruthers

Abstract

The importance of the water-smoking period, the work done, and the difficulties often encountered during this period in firing heavy masses are reviewed. The reasons for and the methods of preventing these difficulties are discussed. Maintenance of the dew-point of the kiln gases several degrees below the temperature of the ware that the gases contact until all the ware is heated to 212°F is suggested as a method for obtaining desired kiln conditions and efficient firing. The dew-point is controlled by rate of combustion and amount of excess air. A control system consisting of an aspiration psychrometer and a pyrometer and the method of using these instruments are described.

I. Introduction

The water-smoking period in a firing process normally requires careful control of the several factors entering into the operation if quality ware is to be produced in minimum time with low firing costs. The principal difficulties that may be encountered, if firing conditions are not correct, are as follows:

(1) Ware may be damaged through cracking, kiln marking, checking or crazing of the ware surfaces, development of blebs or blisters on the surface, and the formation of a weak or "punky" structure.
(2) Efflorescence (drier scum) may be developed, which at higher temperatures is converted into a true scum. This discolors the surface of the ware or prevents glazing of the surfaces.
(3) The kiln may be "sooted," *i.e.*, soot will be deposited on ware surfaces and may fill up some of the flue spaces in the setting. This may cause discoloration of the ware and decrease the rate of temperature advance.
(4) Firing costs may be too high because of the excess time, labor, and fuel required for this part of the process.

The method of firing must be such that it will prevent or eliminate the above-named difficulties. Therefore, a method of control that will aid in securing desired conditions is needed. The following discussion applies particularly to the water-smoking period in firing large masses of ware such as structural clay products and refractories in downdraft kilns.

II. The Water-Smoking Period

This period is ordinarily divided into two parts for an analysis of the process. It consists of (*a*) mechanical dehydration period (start of firing to 300°F) and (*b*) chemical dehydration period (300 to 1100°F). These periods are not fixed and the latter overlaps the oxidation period and in some cases may include it.

During the first period, any mechanical water in the ware not removed in drying and most of the hygroscopic water in the ware are removed. In the second period, the remainder of the hygroscopic water and most of the chemically combined water are driven off. In addition, any pyrite (FeS_2) or siderite ($FeCO_3$) that may be present will be decomposed. In the last part of this period, oxidation of carbon will be started or even completed.

If the ware has been properly dried, it may generally be heated up as fast as possible within certain limitations, provided that condensation of water from the kiln gases on to the ware is prevented. The limiting factors in rate of temperature advance during water-smoking are heat distribution throughout the setting and the amount of oxidation that may be desired from 600 to 1100°F. Practically all of the heat transferred to the ware setting during water-smoking is by convection of the kiln gases.

III. Cause of Difficulties

An analysis of the difficulties encountered indicates that they are most likely to occur during the first stage of the water-smoking period, *i.e.*, up to 300°F. There is practically no possibility of spoiling ware during the second stage of the period if correct conditions have been maintained during the first stage. Ware can also be dam-

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Structural Clay Products Division). Received August 20, 1934.

aged during the oxidation, vitrification, and cooling periods due to improper firing conditions, but quite often the source of the trouble is in wrong conditions during water-smoking.

The various difficulties are due principally to incorrect firing conditions, although wet ware from the drier and sulfur in the ware and fuel may also cause trouble. The conditions that damage ware and reduce the efficiency of the firing process are discussed in the following paragraphs.

(1) Condensation of Water Vapor

Kiln gases contain a considerable amount of water-vapor. When these gases come in contact with any surface at a temperature lower than the dew-point of the gas or are otherwise cooled to the dew-point, condensation of water-vapor takes place. Water condensed on the ware is the primary cause of kiln marking and slumping. Blisters, cracking, and checking of the ware surface are due to wetting of the ware by condensation followed by a rapid rise in temperature.

Then too, if the ware is wetted, sulfur from the kiln gases may combine with the water to form sulfuric acid, which in turn attacks the minerals of the clay to form soluble salts. These are brought to the surface as an efflorescence which is converted to kiln scum at higher temperatures.

The water-vapor in the kiln gases comes from the following sources, *viz.*, (*a*) mechanical, hygroscopic, and chemically combined water in the ware, (*b*) moisture in the fuel, (*c*) combustion of fuel, and (*d*) water-vapor in the air used for combustion.

The humidity (vapor content) of the kiln gases will vary with (*a*) the rate at which water comes from the ware (a function of water concentration in the ware, temperature, thickness of the ware, and the partial pressure of the water-vapor in the kiln gases); (*b*) the rate of fuel consumption, and (*c*) the amount of secondary air used for combustion. The amount of water-vapor brought into the kiln by a unit weight of dry air may not vary during the course of a single day but will vary between wide limits during the year.

The concentration of water-vapor in the kiln gases is greatest just before they leave the kiln; consequently the dew-point is then at a maximum value. The ware is also at the lowest temperature in this region; consequently the maximum amount of condensation will take place in the lower part of the setting if conditions are favorable. Most of the ware damaged due to condensation will be found in the bottom of the kiln. The amount of vapor that may be condensed will vary with the amount of air cooled to its dew-point and the degree of cooling of this air below its original dew-point. There is no further possibility of condensation on a ware surface after it has been heated to 212°F.

The dew-point of a gas depends upon the amount of water-vapor in a unit volume of gas or with a unit weight of dry gas. Therefore, in order to maintain a low dew-point, it is necessary to use a volume of air considerably in excess of that required for combustion. The amount of excess air required is discussed under correct firing conditions.

(2) Kiln Scum

The formation of kiln scum will take place if the surface of the ware is wet and there are sulfur gases in the kiln atmosphere. It seems to be necessary, however, that the amount of water in the ware shall remain constant or shall be increased by condensation if the sulfur gases are to combine with the water. If the kiln atmospheric conditions are such that any mechanical water in the ware is being evaporated, then any kiln scum found on the ware may be attributed to soluble salts that were on the surface of the ware before it entered the kiln, *i.e.*, efflorescence took place during drying.

The use of a large volume of air to prevent condensation prevents the development of kiln scum because the following conditions now prevail in the kiln, *viz.*, (*a*) any mechanical water in the ware is being evaporated; (*b*) concentration of sulfur gas is greatly reduced; (*c*) velocity of the kiln gases is relatively high; and (*d*) condensation is prevented.

The use of a fuel relatively low in sulfur is not needed for water-smoking if the correct air volume is used. All ware should be dry before being set in the kiln.

(3) "Sooting" of Kiln

Soot will be deposited on the ware and in the flue spaces of the setting if the following conditions prevail: (*a*) generation of a large volume of smoke and soot in the fire boxes, (*b*) low velocity of kiln gases through the ware setting, (*c*) water condensed from the kiln gases by the

ware surfaces, and (*d*) wet surfaces of the ware.

Again the use of a large volume of air will eliminate all of the above conditions except the first. If the gases have a high velocity, *i.e.*, a large volume of air is used, the concentration of the soot particles per unit volume of gas is decreased and the particles can not settle out of the gas stream because of their velocity. The use of fuels such as anthracite or wood for water-smoking normally will not be required if sufficient excess air is used to prevent condensation. Also, it would be desirable to have coal fires burn as clear as possible. On many yards, the fires are generally smoldering during the early stages of water-smoking with the development of a large amount of smoke and soot.

(4) High Firing Costs

The cost of firing a kiln of ware includes charges for fuel consumption, labor, power for fans (if used), supervision, and kiln turnover. All of the above items will vary with the amount of time required for the process. Therefore, the ware should be fired at the maximum rate that will give uniform heat distribution and develop correct physical characteristics in the clay body. The report of one extensive kiln-firing investigation[1] indicates that the use of a large amount of excess air during the early stages of water-smoking will permit the temperature to be advanced more rapidly, thus reducing the time for water-smoking and the total time of firing. Attempts to decrease firing time, through a shortening of the oxidation and vitrification periods, generally damage the ware in one way or another and offset other savings.

The consumption of fuel per unit time is increased during a fast water-smoking period because of the heat carried out in the large volume of combustion gases. However, with proper control of air volume and temperature advance, there should be some reduction in fuel consumption for the water-smoking period due to the shorter time required. An optimum rate of temperature advance can be worked out in which fuel and power consumption, labor, and time are balanced to give the least cost for high-quality ware.

(5) Correct Firing Conditions

The difficulties that may be encountered are eliminated if considerable excess air is used during water-smoking. The volume of air used must be sufficient to maintain the dew-point of the kiln gases below the temperature of the ware surfaces in order to prevent condensation. The factors that affect the amount of excess air required are (*a*) type of fuel used, (*b*) amount of moisture in the fuel, (*c*) amount of water in the ware, (*d*) rate at which the water is being removed, (*e*) humidity of the atmosphere outside the kiln, and (*f*) temperature of ware, especially in the coldest parts of the setting. One thousand to 1500% excess air may be required at the start of firing, but as the ware heats up, the amount of excess air may be gradually reduced to approximately 150 to 200% when the ware at the bottom of the kiln has attained a temperature of 250 to 300°F. Control of the excess air, however, should be by regulation of the dew-point of the kiln gases to meet ware temperatures rather than by gas analysis.

Since a strong draft will be needed to move the necessary volume of gases through the kiln and flues, a tall hot stack or an induced draft fan must be used. A damper in the main flue and means for adjusting the volume of air entering each fire box (both below and above the grate) are required to obtain desired conditions. Fuel must be burned at a rate that will furnish sufficient heat to raise the temperature of the setting rapidly. The limit for the rate of temperature advance will be governed by (*a*) the capacity of the draft apparatus, (*b*) amount of water vapor in the kiln gases, (*c*) cost of obtaining the results, and (*d*) temperature distribution throughout the setting.

Fires should burn bright. Considerably more attention to the kiln will be required of the fireman than is generally given.

IV. Control of Firing Conditions

To regulate the volume of excess air to that actually needed to give safe firing conditions, the following procedure is suggested:

(1) Determine the temperature of the ware near the floor of the kiln, using a pyrometer and base metal thermocouple (wire approximately 16-gage) with the hot junction of the latter touching the ware. Only the end of the thermocouple should be bare. (See Fig. 2 for couple assembly.)

(2) Determine the dew-point of the gas at a level just above the point where the temperature of the ware is being measured.

[1] G. A. Bole, *et al.*, "Problems in the Firing of Refractories," *Bur. Mines Bull.*, No. 271 (1927).

Excess air conditions are satisfactory for preventing condensation if the dew-point is just below the ware temperature. A 10° difference will insure a sufficient margin of safety. A greater difference, however, indicates that the air volume should be decreased unless the excess air is needed to control temperature advance. If the dew-point is too high, the flow of excess air through the secondary air openings should be increased or the rate of combustion should be reduced to decrease the rate of vapor formation. The regulation of the kiln draft will vary somewhat from one time to another because of changes in the several factors previously described.

As the ware heats up, it will be necessary to reduce the amount of excess air; otherwise considerable heat will be lost in the stack gases. Condensation will not take place after the ware in the coldest part of the kiln is heated to 212°F. Consequently the psychrometer should be disconnected at that time. Once all the ware is heated above 212°F, the amount of excess air is governed by oxidation requirements.

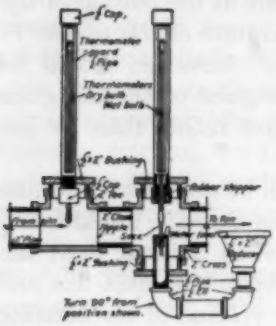

FIG. 1.

V. Determination of the Dew-Point

While several methods may be used to determine the dew-point of a gas, it is believed that the value obtained through the use of a psychrometer (wet- and dry-bulb thermometers) and a humidity chart or vapor-pressure tables is sufficiently accurate for kiln-firing control. An aspiration-type psychrometer is required due to working conditions. This instrument can be built from standard pipe fittings, two thermometers, and a small fan. The assembly of the instrument is shown in Fig. 1, and the method of attaching it to the kiln is indicated in Fig. 2. The thermometers should have a range of 32 to 400°F for the dry bulb and 32 to 250°F for the wet bulb.

The procedure for determining the dew-point with the set-up described is as follows:

(1) The fan should be run for several minutes in order to heat up the system.

NOTE: It would be well to insulate the connection pipe from the kiln wicket to the instrument. If the temperature of the inside of the pipe is below the dew-point of the kiln gas, condensation will take place in the pipe and the instrument readings will be in error.

(2) Continue to draw the hot gases through the instrument, observing the wet-bulb thermometer until a constant reading is obtained, then record the temperatures indicated on both thermometers.

(3) Determine the dew-point from a humidity chart or by calculation and reference to tables.

On the humidity chart,[2] plot the intersection of the dry-bulb and wet-bulb temperature lines.

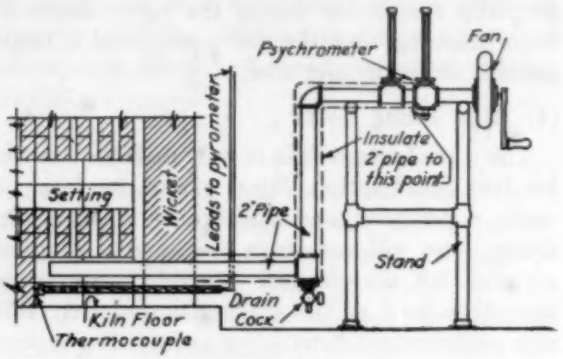

FIG. 2.

Draw a horizontal line from this point to the 100% humidity curve. Project vertically from the intersection of these two lines to the base scale. The temperature value found on the base scale is the dew-point.

NOTE: If the temperatures observed can not be plotted on the humidity chart, the dew-point can be assumed as 5 to 15°F below the wet-bulb temperature. A study of the chart will indicate the assumption to be made.

The dew-point may also be determined by use of the following formula and a set of vapor-pressure tables[3]:

$$p_g = p_w - K(t_g - t_w)$$

Where p_g = partial pressure of water-vapor in kiln gases (mm. Hg).
p_w = vapor pressure of water at wet-bulb temperature (mm. Hg) (obtain from tables).
t_g = dry-bulb temperature.
t_w = wet-bulb temperature.
K = 0.278 (if temperatures are °F).
K = 0.50 (if temperatures are °C).

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[2] Fan Engineering (3rd ed.), a handbook published by the Buffalo Forge Co., Buffalo, N. Y., contains a high-temperature humidity chart suitable for this work.

[3] Walker, Lewis, McAdams, Principles of Chemical Engineering, p. 440. McGraw-Hill Book Co., Inc., 1st ed., 1923.

Solve for p_g and in the tables find the temperature of water for this value of vapor pressure. The temperature noted is the dew-point. This formula is sufficiently accurate for this type of work.

Neither of the temperatures read on the psychrometer will be the true temperature of the kiln gases since there will be some cooling of the gases in delivering them to the instrument. The dew-point determination, however, will be correct, provided condensation of water-vapor in the pipe line has been prevented. The gas must be drawn from the kiln chamber and not from the stack flue because at this stage of the process condensation may be taking place in the kiln flue system. The ordinary humidity chart is for mixtures of dry air and water-vapor, but its use will not introduce serious errors. Hatta[4] describes the construction of a humidity chart for combustion gases.

VI. Summary

(1) Control of the water-smoking period is necessary to fire quality ware in minimum time at a low cost.

(2) Practically all of the difficulties that may arise in the water-smoking period will be avoided if condensation of water-vapor from the kiln gases on to the surface of the ware is prevented.

(3) The dew-point temperature of the kiln gases must be maintained below the temperature of the ware that they contact in the kiln to prevent condensation. Control of the dew-point should be in that part of the kiln where the ware is at the lowest temperature, since the gases heating that region contain the maximum amount of water-vapor.

(4) Air considerably in excess of that required for combustion must be used until all the ware has been heated to 212°F in order to control the dew-point. Rate of combustion is also a control factor.

(5) The kiln system must include a tall hot stack or an induced draft fan in order to move the large volume of kiln gases required. Controls should be provided for regulating the amount of primary, secondary, and excess air entering the fire boxes.

(6) An aspiration psychrometer and a pyrometer to measure the ware temperature are suggested as control instruments. The construction of an aspiration psychrometer for this purpose is indicated.

(7) The optimum rate of temperature advance may prevail during the water-smoking period if the ware is set dry and kept dry.

[4] Sirozi Hatta, "New Humidity Chart Simplifies Combustion Problems," *Chem. & Met.*, **37**, 165 (1930).

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TITANIUM COMPOUNDS AND APPLICATION THEREOF IN VITREOUS ENAMELS*

By C. J. Kinzie and J. A. Plunkett

Abstract

A study was made of the effect of titanium oxide, alumina, zirconia, silica, tin oxide, and antimony oxide on the thermal dilatation, melting point, and fusion flow properties of a simple enamel glass.

I. Introduction

The purpose of this paper is to place on record certain facts relative to the properties of titanium compounds and to clear up certain misconceptions relative to their behavior in enamels.

Titanium was discovered by Gregor in 1791 and was named by Klaproth three years later. It occurs most abundantly as ferrous titanate in the mineral, ilmenite, and also as the oxide in rutile, brookite, and anatase.

Until recently titanium, in the form of rutile, was used in ceramics mainly as a stain in pottery bodies and glazes. Light ivory to dark tan colors are obtained, depending upon the amount used.

Seger[1] showed that titanium has the effect of

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division).

[1] Hermann A. Seger, "The Effect of Titanic Acid on the Fusibility of Fire Clays," Collected Writings, Vol. 1, pp. 519–20.

lowering the refractoriness of certain clay mixtures. Rossi showed that titaniferous slags were more fluid by virtue of their titanium content. Leuchs and Leuchs[2] made important disclosures in 1893 relative to the effect of titanium on the acid-resisting properties of enamels for iron.

Landrum and Frost[3] reported the results of certain experiments with rutile in vitreous enamels and concluded that this element, titanium, contributed more good properties than bad ones. The observations of these persons making a study of titanium disclosed that titanium is a flux.

Unfortunately, in many references, particularly in the patent literature, titanium is classified as an opacifying element with tin and zirconium oxide as a mill addition for enamels.

Not until recently has pure titanium oxide been available at prices which would permit its use in anything except ceramics for artistic purposes.[4] The fact that titanium oxide was developed commercially at a low price for the paint pigment trade has resulted in its more general use in enamels.

II. Physical and Chemical Properties

The formula for titanium oxide is given as specific gravity about 3.95; index of refraction, 2.50 to 2.90; color, white; and melting point about 1800°C.

Titanium oxide must be considered as a secondary flux because it must first combine with other enamel ingredients before its fluxing power can be exercised.

Titanium can be obtained as sodium titanium silicate, having a melting point of about 900°C. This compound is a primary flux and represents a convenient and effective method of introducing titanium in enamel batches.

Sodium titanate is another means of introducing titanium, but of the two, sodium titanium silicate is the more effective and economical to use.

The oxide and its compounds are readily reduced; for instance, in silicate melts reducing conditions produce blue-colored glasses. In solution form, such as the sulfate and chloride in aqueous acid solutions, the normal titanium salt is reduced to lower oxide form in contact with metallic zinc or iron, which fact is the basis for the quantitative volumetric assay of titanium when present in amounts of more than about 1%.

Titanium solutions, sulfate and chloride, when treated with peroxide of hydrogen, yield a characteristic yellow color which is the basis for the colorimetric determination of the element when present in amount less than about 1%. The peroxide reaction is very delicate and minute amounts of titanium are readily determined.

The pure oxide supplied to the ceramic trade is the most powerful paint pigment known and because of this fact, large-scale and low-price development have resulted. The remarkable pigmenting strength of titanium oxide has, no doubt, led to the conclusion by some persons that it would be a suitable white pigmenting agent for vitreous enamels. This, however, has not proved to be the case.

III. Behavior of Titanium Oxide in Vitreous Enamel

Titanium oxide, much like zinc oxide, when used as a mill addition, readily dissolves during the firing of the ware, usually producing an off-color enamel, low in opacity and rather poor as to surface quality. Its function in enamels lies in its specific properties when used in the raw batch, while in some cases, as noted by Landrum and Frost,[3] it will cause opacity by crystallization. Opacity, therefore, is a minor function of titanium oxide in enamels.

The following examples are presented to illustrate the behavior of titanium in developing opacity by crystal formation and also to show the marked effect of titanium in lowering the solubility of enameled surfaces in acids.

EXAMPLE A

				Example	
Na_2O	9.20	Al_2F_6	6.40	A	Original A
K_2O	2.20	B_2O_3	10.00	B	A + 10SiO_2 in batch
CaF_2	2.30	SiO_2	50.70	C	A + 3TiO_2 in batch
CaO	1.30	Al_2O_3	4.40	D	A + 6TiO_2 in batch
P_2O_5	0.40	Sb_2O_3	3.50	E	A + 9TiO_2 in batch
NaF	9.60			F	A + 13TiO_2 in batch
			100.00		

Batches of about two pounds were smelted in clay crucibles in a gas-fired furnace, observations being made as to fluidity during the pouring of the melt. The results were as follows:

[2] Ger. patent, 9611.

[3] R. D. Landrum and L. J. Frost, "Titanium Enamels," *Jour. Amer. Ceram. Soc.*, 3 [4], 316 (1920).

[4] In 1929 pure TiO_2 was priced at 40 cents per pound; at present white 98% oxide is available for less than 20 cents per pound.

Example

A At 1150°C; quite viscous; could not be poured
B Melt gummy at 1160°C; temperature raised to 1200°C; too viscous to pour freely; had to be assisted by drawing from the crucible
C Melt noticeably more fluid than A; poured freely at 1150°C
D Melt more fluid when compared with C; poured freely at 1150°C
E Melt very fluid; poured freely at 1150°C
F Melt very fluid; poured freely at 1150°C

In all cases the titanium oxide addition made the melt less viscous, the viscosity decreasing as the titanium was increased in the batch. Millings were made without opacifier additions, using only 6% Vallendar clay and 1/2 of 1% magnesium carbonate. It was noted that whereas A and B required about 40% of water for milling, frits C and D and E and F required less water, the amount decreasing from C to F, 35% being about right for F.

Flat pieces and miniature wash basins were enameled, the ware being fired at 1540°F for the period of time which yielded matured enamel in each case.

Quantitative acid-resistance tests with acetic acid solution in water were made with the miniature wash basins.

The opacity increased as the titanium content became greater and the color tended away from the white. In example F, the color was a strong tan and the opacity very high. In F, luster was lowered by citric acid in small spots which indicated that crystals had formed and were at (or close to) the surface and that acid affected neither the crystal nor the surrounding glass.

These experiments confirm the observations of Landrum and Frost[3] that in the conventional formulas the titanium tends to crystallize out producing opacity and, incidentally, off-color enamels.

These experiments illustrate the result when titanium is used in the conventional formula and show why attempts to use titanium this way have failed to produce white enamels.

The D formula of the above series is a fairly good enamel when milled with 8% Opax and used on hollow ware; the color is cream-white. The F formula with Opax gives a good tan color.

In another series of experiments using an entirely different formula, an enamel was made having the following calculated composition.

EXAMPLE G

Na_2O	6.20	ZnO	11.00
R_2O	4.40	B_2O_3	10.80
K_2O	4.80	SiO_2	43.90
CaF_2	4.80	Al_2O_3	6.70
NaF	1.90	TiO_2	9.10
Al_2F_6	1.20		
			100.00

The frit was a tan color and practically clear but when milled with 6% clay and water, applied to ground-coated sheet iron, and fired, the enamel was an opaque blue. In this case the crystals responsible for the titanium opacity, possibly a combination of zinc, alumina, and titanium, were of a blue color, quite in contrast with the tan obtained in the first series described.

Using the high zinc formula referred to with varying percentages of titanium, colors ranging from pea green to strong blue-grays have been produced.

Based on the experiments and results described it will be seen that some radical changes in formulas were required to take advantage of the desirable effects of titanium oxide, namely its specific effect of markedly increasing the resistance of enamel toward fruit acids while at the same time lowering the refractoriness of the enamel.

During the course of numerous experiments of which the above were a part, it was noted that if the clay were omitted from the mill batch no blue enamel was obtained, and experiments have produced strong evidence that the development of these various colors in titanium enamels is closely associated with the presence of aluminum and its compounds.

While none of the foregoing experiments resulted in the development of a satisfactory white acid-resisting enamel, there resulted several formulas of interest, such as cream or light tan enamels of good resistance to fruit acids. The following is a typical example:

RESULTS OF ACETIC ACID TESTS

Enamel	A	B	C	D	E	F
Grams loss	0.018	0.0110	0.0080	0.0060	0.0040	0.0050
Spot test (15% citric acid, 15 min.)	Badly etched	Etched	Slightly etched	Only shadow marked	Only shadow marked	Slightly etched

EXAMPLE H

	Batch formula	Feldspar analysis (%)	
Feldspar	22.02	SiO_2	66.02
Quartz powder	32.00	Al_2O_3	18.62
Borax	24.75	NaKO	15.08
Soda ash	3.51		
Sodium nitrate	3.50		
Fluorspar	2.15		
Calcium carbonate	2.23		
Bone ash	0.86		
Cryolite	16.17		
Antimony oxide	3.50		
Titanium oxide	6.20		
Raw total	116.89		
Melted	100.00		

Calculated composition (%)				Mill mix	Parts
Na_2O	8.65	Al_2F_6	6.47	Frit	100
K_2O	2.00	B_2O_3	9.06	Opax	8
CaO	1.25	SiO_2	46.52	Enameling clay	6
CaF_2	2.15	Al_2O_3	4.10	Magnesium carbonate	0.25
P_2O_5	0.40	Sb_2O_5	3.50	Water	37
NaF	9.70	TiO_2	6.20		
			100.00		

The above enamel when fired to matured surface, has a good luster, cream color, and a good resistance to fruit acids. Its solubility is low, but it shows a slight etching with citric acid. It should be a good enamel for hollow ware and for other applications where an enamel is required to stand contact with fruit acids and where absolute resistance is not required.

By lowering the silica content several per cent, at the same time increasing the titanium oxide a like amount, and using the mill mix as given above, an enamel can be produced possessing a rather pleasing dark tan color.

The above formulas and data represent useful information in enamel formulation for cases requiring enamels not white but of color tones from light cream to decided tan.

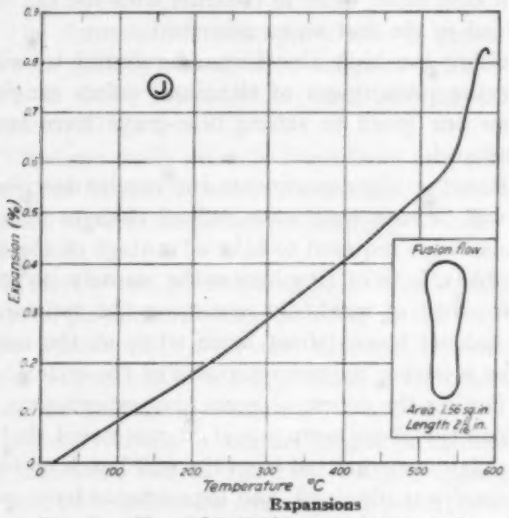


FIG. 1.—(J) 19°C–530°C = 114.6 × 10^{-7}.
19°C–579°C = 148.3 × 10^{-7}.
530°C–579°C = 499.5 × 10^{-7}.
Expansions

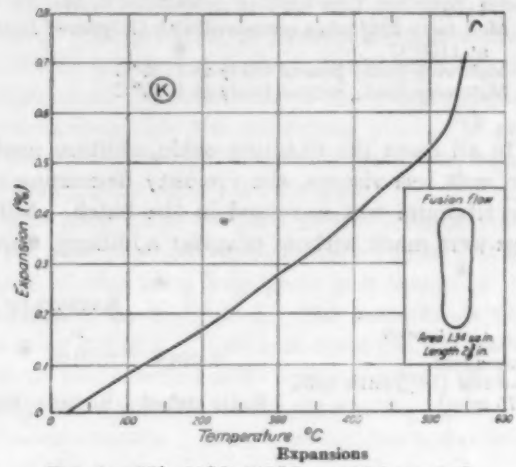


FIG. 2.—(K) 20°C–525°C = 116.0 × 10^{-7}.
20°C–560°C = 144.9 × 10^{-7}.
525°C–560°C = 562.3 × 10^{-7}.
Expansions

An important achievement in this research on enamels of the acid-resisting type has been the development of aluminum-free enamels, containing in some cases as high as 14% TiO_2, which with a moderate clay addition mature to a white color at temperatures of 1500°F. Enamels of this type containing relatively high titanium percentages are characterized by a great brilliance of surface.

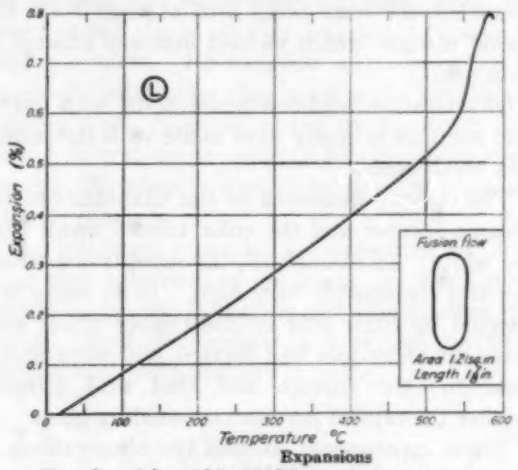


FIG. 3.—(L) 15°C–539°C = 112.9 × 10^{-7}.
10°C–584°C = 139.7 × 10^{-7}.
539°C–584°C = 451.1 × 10^{-7}.
Expansions

High titanium enamels properly formulated can be made which mature at low temperatures and are resistant to fruit acids.

The following enamel, although not the best one developed, is presented as being typical of the general plan as to formula.

EXAMPLE I

FORMULA FOR HIGH TITANIUM WHITE ACID-RESISTING ENAMEL

Meltopax	7.15	Titanium oxide	14.00
Quartz powder	40.97	Antimony oxide	7.00
Borax	27.33	Fluorspar	5.00
Soda ash	17.56	Raw total	123.51
Sodium nitrate	3.50	Melted total	100.00

Meltopax is a sodium zirconium silicate of the following chemical analysis:

Chemical analysis	(%)	Calculated composition melted	(%)
ZrO_2	56.00	Na_2O	17.00
SiO_2	28.40	CaF_2	5.00
Na_2O	14.00	B_2O_3	10.00
Others	1.60	SiO_2	43.00
		Sb_2O_5	7.00
	100.00	ZrO_2	4.00
		TiO_2	14.00
			100.00

The batch should be thoroughly mixed and special attention given to the matter of rubbing in the titanium oxide and bringing it into intimate contact with other more fusible batch ingredients.

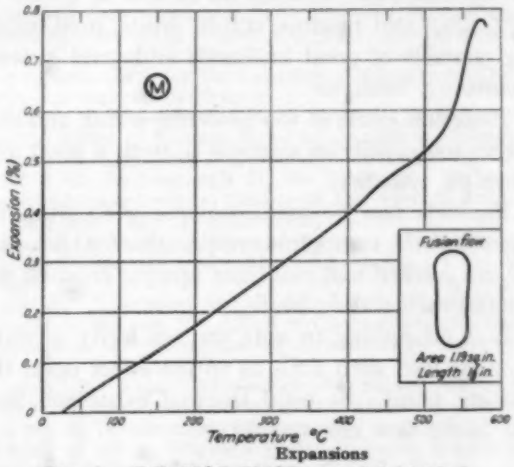


FIG. 4.—(M) 23°C–534°C = 115.2×10^{-7}.
23°C–570°C = 141.9×10^{-7}.
534°C–570°C = 520.8×10^{-7}.

Smelt at as low a temperature as practical and, after all raw materials have apparently dissolved, continue heating for about one-half hour. The temperature particularly during the fining period should be kept below 1900°F.

Mill with 3% Illinois kaolin and 6% Opax and water, using a small amount of either ammonium carbonate or hydrochloric acid to set the enamel up.

Fire the ware at about 1500°F, giving some-

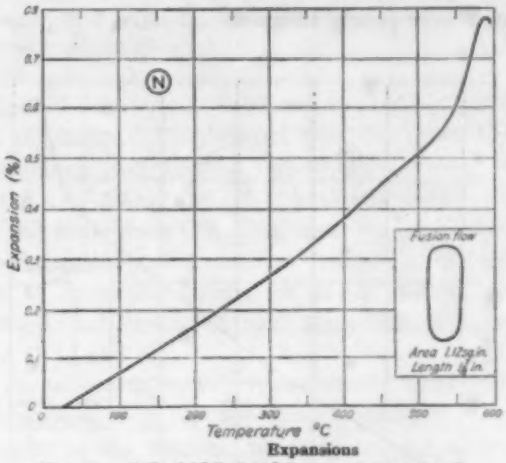


FIG. 5.—(N) 28°C–540°C = 112.1×10^{-7}.
28°C–589°C = 138.9×10^{-7}.
540°C–589°C = 419.0×10^{-7}.

what more than the customary time in the furnace after the enamel has matured.

The enamel of example I is presented mainly to show that with proper formulation white enamels can be made containing a high content of titanium. The enamel of example I may prove to be a good starting point in connection with the development of white acid-resisting enamels for various purposes.

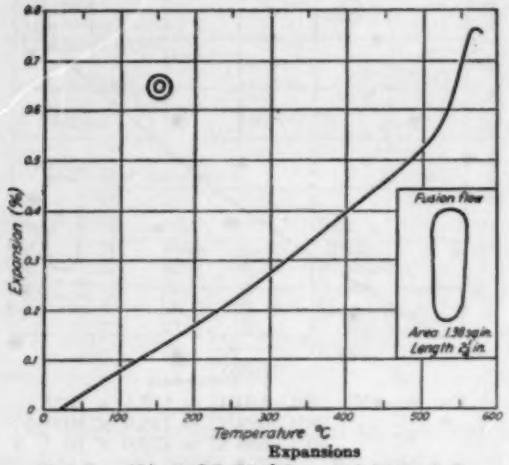
IV. Effect of Titanium on Thermal Expansion, Fusion Flow, and Melting Point of a Simple Enamel Glass

A study was made of the effect of titanium oxide as compared with alumina, zirconia, silica, tin oxide, and antimony oxide upon the thermal dilatation, melting point, and fusion flow of one simple enamel glass. For this work a formula was selected in which each of these oxides dissolved forming a clear glass.

The base formula used was of the following composition (calculated):

	(%)
Na_2O	14.14
BaO	27.06
B_2O_3	9.46
SiO_2	42.73
Variable	6.61
	100.00

In preparing the batches, special care was used in the selection of materials and in blending to insure rapid combination of the materials, in each case subjecting the charge only to that amount of heat required to melt and combine and avoiding prolonged heating which might be required if the batch were poorly blended.



Expansions

FIG. 6.—(O) 21°C–521°C = 113.9 × 10^{-7}.
21°C–565°C = 139.8 × 10^{-7}.
521°C–656°C = 434.6 × 10^{-7}.

The following data will identify each of the six enamels:

Example		
J	6.61% TiO_2	+ 98% pure
K	6.61% Al_2O_3	Supplied as pure aluminum hydrate
L	6.61% ZrO_2	98½% pure
M	6.61% SiO_2	+99% pure
N	6.61% SnO_2	+99% pure
O	6.61% antimony oxide	98% pure

All charges smelted easily to essentially clear glasses.

Each of the six glasses was subjected to the following tests: (1) a study of thermal expansion properties by the interferometer method and (2) a study of the fusion-flow properties by the method described by Kinzie.[5]

The results of each thermal expansion determination and the fusion-flow behavior of each glass at one temperature (1520°F) are shown in Figs. 1 to 6, as well as by planimeter measurements of area covered by enamel flow. These have been added to thermal expansion data in order to compact the presentation of all this data.

[5] C. J. Kinzie, "Method for Study of Relative Viscosity of Enamel Glasses," *Jour. Amer. Ceram. Soc.*, **15** [6], 357–60 (1932).

V. Summary

Titanium oxide increases the fluidity of the enamel melt. This point is proved in a series of examples (A, B, C, D, E, and F), in which increasing TiO_2 additions to formulas increased the fluidity of the melt.

Titanium oxide produces enamel glasses or frits which at 1520°F are more fluid than those in which like additions of Al_2O_3, ZrO_2, SiO_2, SnO_2, and Sb_2O_5 were made, as proved by examples J, K, L, M, N, and O (Figs. 1 to 6).

Titanium oxide, when used with the usual enamel batch ingredients, tends to produce colored enamels. This color will vary depending upon other ingredients in the batch as well as upon the amount and kind of mill addition.

Enamels have been produced having cream to dark tan tones and another series, having colors ranging from very light blue to fairly dark bluish gray, evidently by a combination of titanium, zinc, and aluminum. Certain of these titanium-bearing, colored enamels should be of interest in the manufacture of enameled ware.

Antimony-bearing enamels, designed especially for titanium, can contain up to and in excess of 14% TiO_2 and produce stable, white, acid-resisting enamels of great brilliance and good general enameling behavior.

Titanium oxide is too powerful a flux and dissolves too readily in enamels to form a good mill addition opacifier.

Enamels can be made opaque with titanium alone, but the compounds responsible for the opacity are colored and resultant opaque enamels are colored rather than white.

It is interesting to note the similarity of SnO_2 as compared with ZrO_2 as to the effect upon the melting point, the total thermal expansion, and the fusion-flow characteristics.

Acknowledgment The authors wish particularly to extend acknowledgment to C. H. Commons and J. B. Miller who made the thermal expansion studies and ably assisted in the accumulation of the various data presented in this paper.

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MICRO-GAS ANALYSIS OF GAS TRAPPED IN VITREOUS ENAMELS ON ENAMELING IRON DURING FIRING*

By S. E. Freeman and V. W. Meloche

Abstract

A technique is described which is available for the analysis of trapped gases in vitreous enamels. The composition of gases trapped in a special enamel coat has been given.

I. Introduction

In the course of some investigations on the adherence of enamel to iron, the composition of the gases evolved during the firing period was desired. The rôle played by gases in this process has been studied indirectly by the alteration of the furnace-atmosphere composition by several investigators.[1] Investigation of a more direct nature on the composition of gases in glass was made by Enss[2] and Dalton.[3] Gases in iron, with particular reference to enameling iron, were studied by Baker and Joublanc,[4] using fairly large samples in a closed system containing helium. The relative absorption or expulsion of the particular gas was determined during increasing and decreasing temperatures. More recently a spectrographic examination was made by Lucian and Kautz[5] wherein the gases were collected in a special tube and excited by electrical discharge. They found that the gases from enameling iron heated below 650°C were H_2, H_2O, CO, CO_2, and N_2; between 650°C and 870°C they were CO, CO_2, and N_2; gases from dried ground-coat enamel at temperatures below 870°C consisted chiefly of H_2O. Gases from ground-coat enameled iron contained H_2, H_2O, CO, CO_2, and N_2.

These results, however, are chiefly qualitative. Since we wished to know the composition of gas present in the enamel, we tried to find a technique by which this information could be more easily obtained. While the composition of the gas entrapped during the firing of the special ground coat is described in the present paper, it should be particularly noted that the authors wish to present an existing microanalytical technique which may be of use to ceramists in similar studies.

II. Methods and Materials

The enameling iron used was a commercial enameling iron, 20-gage, which had been pickled fifteen minutes in 15% hydrochloric acid, washed and scrubbed, boiled in 5% sodium hydroxide solution, and washed and dried. The ground-coat enamel was that used by King[6] in his investigations on adherence with the exception that no cobalt, nickel, or manganese oxides were added. The enamel was applied by spraying to an equivalent of about 50 grams per square foot, dry weight, total both sides. The extra thickness of the coat was used to increase the amount of gas entrapped by the enamel during firing. The samples were fired at 840°C for 2.25 minutes.

The gases were sampled by crushing the enamel on the iron under a solution of glycerine plus water (50–50) saturated with sodium chloride. The enamel which flaked off was crushed

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* Listed on the Annual Meeting Program, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division). Received August 25, 1934; revised copy received December 17, 1934.

A contribution from the Laboratory of Inorganic Chemistry, University of Wisconsin.

[1] (*a*) A. I. Andrews and E. A. Hertzell, "Progress Report on Effect of Furnace Gases on Quality of Enamels," *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 214, Aug. (1930).

(*b*) A. I. Andrews and H. W. Alexander, "Effect of Smelter Atmospheres on Quality of Dry-Process Enamels for Cast Iron," *ibid.*, No. 227 (1931).

(*c*) R. D. Cooke, "Effect of Furnace Atmosphere on Firing of Enamel," *Jour. Amer. Ceram. Soc.*, **7** [4], 277 (1924).

(*d*) W. C. Rueckel and R. M. King, "Mechanics of Enamel Adherence, II. Effect of Composition and Firing Atmosphere on Adherence of Ground-Coat Enamels," *ibid.*, **14** [10], 782 (1931).

(*e*) R. M. King, "Mechanics of Enamel Adherence, VIII: (*a*) Apparatus for Firing Enamels under Accurate Control of Temperature, Pressure, and Atmosphere; (*b*) Studies in Firing Enamels under Reduced Pressures," *ibid.*, **16** [5], 232 (1933).

(*f*) E. T. Allen and E. G. Zies, "Methods of Gas Analysis with Special Reference to Boric Acid and the Two Oxides of Arsenic," *ibid.*, **1** [11], 739 (1918).

[2] J. Enss, "Analysis of Gas Content of Glass Bubbles," *Sprechsaal*, **66** [39], 662–66 (1933).

[3] R. H. Dalton, "Gases in Glass," *Jour. Amer. Ceram. Soc.*, **16** [9], 425–32 (1933).

[4] R. W. Baker and J. C. Joublanc, "Study of Gases in Enameling Iron," *ibid.*, **16** [9], 437–41 (1933).

[5] A. N. Lucian and K. M. Kautz, "Study of Gases in Enameling Iron," *ibid.*, **17** [6], 167 (1934).

[6] G. H. Spencer-Strong and R. M. King, "Mechanics of Enamel Adherence, V. Study of Enamel-Metal Contact Zones by Chemical Methods," *ibid.*, **15** [9], 481 (1932).

with a nickel-plated steel rod while the sample was held under a small funnel leading to the gas holder (Fig. 1). The sample, funnel, and gas holder were totally immersed during this process. The bubbles of gas were trapped in the glass bulb immediately after they were released from the enamel. When a gas sample of sufficient size was obtained, the gas was transferred to a bulb over mercury. This was done by removing the small funnel shown in Fig. 1, closing the end of the bulb with a finger, and transferring the bulb to the mercury trough. It is best to have the fingertip covered with a rubber stall which is wet with confining liquid in order that the gas sample is not contaminated with outside gas. When the bulb containing the gas sample was clamped in position over the mercury trough and the finger was removed, the excess aqueous solution was removed by means of a capillary pipet. In order to insure further the absence of moisture, the capillary buret was then used to transfer the sample to a second dry bulb where the gas was finally dried by a bead of phosphorous pentoxide. The gas was analyzed with the Leighton micro-gas apparatus[7] using the technique and precautions recommended. Using this method, samples of 25 cubic millimeters are adequate for a complete analysis. This amount of gas was easily secured from 3 three-inch disks. The precision of the method is nearly as great as that of the standard macro-methods of gas analysis. Water was absorbed by P_2O_5, oxygen by yellow P, carbon dioxide by KOH, carbon monoxide by Ag_2O, and the residual gas exploded by heating the tube after the addition of a known amount of pure oxygen. Any carbon dioxide formed by this combustion was absorbed by KOH and is listed as an unknown hydrocarbon. Hydrogen was determined by contraction in volume and nitrogen by difference. That the unknown hydrocarbon mentioned is an error due to the incomplete removal of carbon monoxide by the Ag_2O is hardly likely since Ag_2O has been shown to be a very effective absorbent for small amounts of carbon monoxide.

FIG. 1.

In the above description of the gas analysis, details have not been given because these have already been clearly presented in the literature cited.

The water-glycerine-salt solution was used as the preliminary confining liquid after the examination of solubility data[8] and trials with test samples. Such an aqueous solution has the lowest solubility for carbon dioxide and other gases of any practical confining liquid except mercury. Although the solubility for carbon dioxide is low, the water-glycerine-salt solution dissolves appreciable amounts of this gas. For this reason the results for carbon dioxide may be slightly low. The results for the other gases should be reasonably precise. The confining aqueous liquid was made from distilled water and allowed to stand for a week to insure the complete removal of gases made less soluble by the salt and glycerine. Boiled water was not used since the solubility of the gases would be increased. It was thought that saturation of the confining liquid by air was preferable because only a limited amount of sample was available. The only gas in the sample which might show an appreciable solubility in the confining liquid would then be carbon dioxide. Using the water-glycerine-salt mixture as a preliminary confining liquid under the conditions described, it is not likely that any serious error would be introduced by the final equilibrium between the gas sample and the aqueous confining liquid.

III. Results

Several samples were prepared according to each of the following conditions: (1) slip aged 3 days, (2) slip aged 2 weeks, (3) slip aged 4 months, and (4) slip aged 2 weeks, aluminum powder added to 5% concentration.

These samples were all sprayed and fired in the manner described above. Very marked gassing was noted when aluminum powder of 5% concentration was used. Smaller amounts of aluminum tend to reduce gassing.

Analyses of gas samples taken from the enamels described above are presented in the following table:

[7] (*a*) Blacett and Leighton, *Ind. Eng. Chem., Anal. Ed.*, 3, 266 (1931).
(*b*) Blacett, MacDonald, and Leighton, *ibid.*, 5, 272 (1933).

[8] A. M. Comey and D. A. Hahn, A Dictionary of Chemical Solubilities, p. 173. The Macmillan Co., 2nd ed., 1921.

Sample No.	Composition (%) O_2	CO_2	CO	H_2	Hydrocarbon	N_2
1	12.63	1.04	17.03	31.85	0.98	36.47
2	5.97	0.74	17.57	7.47	2.82	65.43
3	2.60	0.00	15.77	57.81	3.54	20.28
4	5.59	1.03	26.00	41.49	4.44	21.45

IV. Conclusions

The gases present agree with those reported by Lucian and Kautz[5] from spectrographic data except for the oxygen content. Since the enamels used here were free from Co, Ni, and Mn and were not previously fired, some additional reactions not occurring in a reboil fire may explain its presence. The quantitative relationships of the gases show the same general trend for all samples except for the abnormally low hydrogen and high nitrogen in sample No. 2. The presence of carbon dioxide could be due to a shift in the equilibrium $2CO_2 = 2CO + O_2$ as the sample was cooling.

The composition of gases entrapped in samples of a special ground-coat enamel has been described. The authors wish to direct attention to the use of the microanalytical method described for the examination of gases in problems of this nature.

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CONSTITUENTS AND PROPERTIES OF "RADEX" MAGNESITE BRICK*

By P. P. Budnikoff and B. J. Pines

Abstract

Physical and chemical data on "Radex" magnesite brick are given, macro- and micro-structure studies described, and details of X-ray tests are noted. The brick is highly resistant to basic slag, and has spalling resistance under rapid temperature fluctuations.

I. Introduction

Magnesite brick belongs to the highly refractory materials; its refractoriness corresponds to a pyrometric cone equivalent of 40 to 41, or 1920 to 1960°C and over. This refractory material is also very resistant to the influence of basic slag. In contrast with these valuable properties, it has one essentially negative property, *viz.*, small resistance to spalling under sharp fluctuations of temperature.

The Oesterreichisch-Amerikanische Magnesit A.-G. in Radentheim, Kärnten (Austria) has put on the market lately a new kind of magnesite brick named "Radex," which the manufacturer claims to be free from the principal demerit of ordinary magnesite brick, *i.e.*, easy formation of cracks. "Radex" withstands over thirty repeated heatings to 950° and subsequent coolings in running water. According to K. Endell, the resistance to spalling of magnesite brick depends on the microstructure of periclase crystals which form at the high firing temperature of magnesite. In the spalling-resistant magnesite brick of "Radex" type there forms, according to Endell, sharply terminated periclase grains with distinct multiple jointing and gliding planes which acquire plastic properties at high temperatures. During the test of the spalling capacity of "Radex," the strains that appear in the brick are being cleared off owing to splintering of separate periclase crystals into smaller ones and their gliding in the direction of the jointing planes. The aptitude of periclase crystals to go over to a plastic state depends on a variety of causes (the presence of admixtures, temperature and length of firing, size of crystalline grains, disturbances in the crystalline structure owing to pressure, etc.).

This explanation, according to the writers, does not fully exhaust the question as to the causes of resistance of "Radex" to spalling and does not entirely correspond with the investigation on it, described in this paper.

According to published data,[1] the "Radex" magnesite brick has a beginning of shrinkage under load of 1 kg./cm.^{2} at a temperature of 1550 to 1650°C. The additional expansion of the brick after heating for 4 hours at 1550°C has

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received July 25, 1934.

[1] (*a*) K. Endell, *Stahl u. Eisen*, **52** [31], 759–63; [35], 856 (1932); *Arch. Wärmewirtschaft*, **12**, 320 (1932). (*b*) K. Endell und W. Müllenseifen, *Ber. deut. keram. Ges.*, **14**, 16–28 (1933). (*c*) A. Freberg, *Ogneuporui*, **1**, 29 (1933).

a value from 0 to 0.3%. The volume porosity varies from 18 to 24%. The chemical resistance of the brick to basic slag is very high.

Magnesite brick of this type proved to be very resistant in the crown of open-hearth furnaces

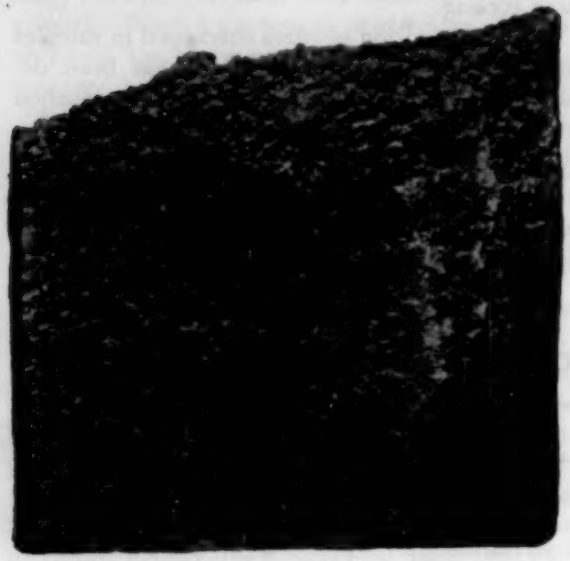

FIG. 1.

and other heating structures. It is also resistant to the influence of Portland cement clinker.[2]

II. Test Results on Brick

(1) Chemical Composition A sample of "Radex," was subjected to investigation and the results are given in the following paragraphs.

CHEMICAL COMPOSITION OF "RADEX" MAGNESITE BRICK

MgO	83.54	Refractoriness	Over cone 39
SiO_2	3.60	Specific gravity	3.57
Al_2O_3	4.07	Water-absorption capacity	4.9%
Fe_2O_3	5.17	Volume porosity	14.7%
CaO	2.60	Bulk density	3.0
MnO	0.19		

Spalling resistance: 15 heatings to 950°C and subsequent coolings in running water without the formation of cracks and without loss of weight.

(2) Macrostructure "Radex" magnesite brick has a homogeneous small-grained fracture (Fig. 1).

(3) Microstructure The inspection of a thin slide with a microscope shows the following picture (Fig. 2, 80 diameters; crossed nicols). The fundamental base consists of brownish grains of periclase; these grains have an angular, roundish shape and their diameter does not surpass 0.12 millimeter. They are isotropic and have distinct cleavage cracks 11(001).

FIG. 2.

Over the whole field there are irregularly scattered anisotropic yellowish-brown forsterite grains of the same size as the periclase grains. Their shape is irregular and the interference coloring is

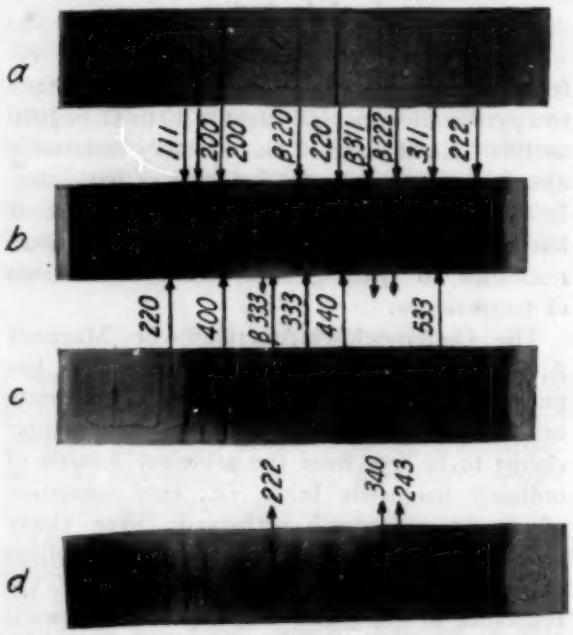

FIG. 3.—(*a*) Periclase, (*b*) "Radex," (*c*) spinel, and (*d*) forsterite.

bright. The majority of the grains show one system of cleavage cracks, (010) each, and only some grains demonstrate two systems of cracks, (010) and (001).

[2] The method of production of this brick has not been published.

At places the forsterite grains accumulate, forming small stains.

(4) X-Ray Investigation An X-ray photo obtained from a sample of "Radex" by the Debye method (Fig. 3*b*) shows the presence, in addition to the periclase lines, of a system of additional lines which belong to some new mineral. For comparison, an X-ray photo of periclase is shown in Fig. 3*a*.

Table I

Comparison of an X-ray Photo with the Structures of Periclase, Spinel, and Forsterite (Olivine)

Order of lines	Intensity	Angle of reflection θ with correction	$\sin^2\theta$	Periclase (*hkl*)	Spinel Intensity	Spinel (*hkl*)	Spinel $\sin^2\theta/\Sigma h$ *	Forsterite Intensity	Forsterite (*hkl*)	Forsterite $\sin^2\theta$ (computed)	
1	Feeble	23.2	0.155		Medium	220	0.0194				
2	"	25.4	0.184	111 β							
3	"	27.0	0.206		Feeble	311	0.0187	Strong	131	0.208	Coincides with the lines of MgO
4	Medium	27.8	0.216	111				"	112	0.216	
5	"	29.5	0.242	200 β				"	122	0.251	
6	Very strong	32.9		200							
7	Feeble	34.2	0.316		Feeble	400	0.01975				
8	"	39.2	0.400								(222) of monticellite, $\sin^2\theta$ = 0.397
9	"	40.8	0.427					Very strong	222	0.428	
10	"	42.0	0.447		Medium	333					
11	Strong	44.5	0.492	220 β				Strong	232	0.490	Coincides with the lines of MgO
								"	133	0.500	
12	Medium	47.3	0.540		Very feeble	333	0.0200				
13	Very strong	50.2	0.592	220				Strong	004	0.585	
								"	223	0.616	Coincides with the lines of MgO
14	Medium	53.25	0.642		Very feeble	440	0.02005	"	260	0.684	
15	"	55.3	0.676	311 β				"	340	0.722	
16	Strong	59.25	0.740	222 β							
17	Very strong	64.7	0.820	311							
18	Feeble	68.4	0.865		Feeble	533	0.0201				
19	Very strong	70.8		222							
					Average		0.01985				

* a = 8.125.

It can be seen that "Radex" has strongly expressed periclase lines; the additional lines are much fainter. This shows that the fundamental mass of "Radex" consists of periclase; the admixtures apparently only cement the periclase.

The additional lines observed do not quite coincide with the forsterite lines (Fig. 3*d*).

In Table I measured reflection angles for these lines and the manner of indexing them are shown.

All lines can be indexed, if we suppose the simultaneous presence of the following minerals: forsterite, monticellite, and spinel, the last one only in the magnesia-alumina form (Fig. 3*c*). The parameter of the spinel crystalline structure, a = 8.125 Å, is in accordance with this conjecture. The distribution of the lines of the X-ray photo between these minerals is shown in Fig. 3.

The table shows that only very strong lines of forsterite and only the strongest line of monticellite appear on the photo of "Radex."

Data obtained by the X-ray method are in full accordance with the chemical analysis and petrographic data; of course, it must be taken into consideration that cubic spinel that does not give a double refraction is sometimes difficult to distinguish from cubic periclase by microscopic inspection.

III. Conclusions

The results obtained show that "Radex" is a refractory material whose structure resembles the material that forms itself in the hearth of open-hearth furnaces after sintering.

At the same time this shows the way that must be taken in attempting to produce "Radex." The X-ray photo of a fusion of 90% MgO with 10% of open-hearth slag obtained in our laboratory demonstrates that this method can lead to sound results. It can be seen that all lines of this photo are very close to the "Radex" lines, *i.e.*, that the structure of this material is the same as that of "Radex."

Of course a certain quantity of refractory material should be made in this way and its properties should be verified.

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THE GUARDED RADIATION PLATE METHOD FOR THE DETERMINATION OF THERMAL CONDUCTIVITY OF REFRACTORIES AT ELEVATED TEMPERATURES*

By C. A. Peterson

Abstract

A new hot-plate apparatus and method for measuring thermal conductivities at elevated temperatures are shown and an accurate means of measuring the rate of heat flow through the test piece by means of a calibrated heat loss or "radiation" plate is described. Normal heat flow is assured by means of guard heaters around both hot plate and radiation plate. Test pieces can be cut from one-half of a 9-inch straight brick. The calculation of results is shortened to a few minutes, calibration can be checked in place, and construction details are shown. The results on products in the market will be given in a subsequent paper.

I. General

The radiation plate for measuring heat losses from heated surfaces has been used for many years. Its application, however, to the measurement of thermal conductivity was only recently made by T. H. Blakeley and J. W. Cobb when in 1932 they built an electrically heated hot-plate apparatus and used a radiation plate to measure the rate of heat flow through the test piece.[1]

II. Description of Apparatus

The apparatus employed in this work uses a box of fiber board, 28 inches square and 15 inches high, with a slide bottom arranged to drop the loose kieselguhr packing into a metal box when changing test pieces. Figure 8 shows the apparatus ready for use.

The arrangement in general consists of a test area, 4 by 4 inches, surrounded by a guard area 2 inches wide. The entire area, 8 by 8 inches, is heated from below by a guarded hot plate, 8 by 8 inches, consisting of a central area, 4 by 4 inches, with a guard 2 inches wide separated by a $^1/_8$-inch gap each heated separately by electrical resistances. The test piece and guard of the same material are covered with pieces of insulating block of the same size as the test piece and guard to obtain higher mean temperatures of the test piece without raising the temperature of the radiation plate above 300°C.

The radiation plate is placed on top of the whole column and is so positioned that its top surface is $^1/_2$ inch below the top edge of the box.

The essential parts of the apparatus are (1) fiber case, (2) heater plate, (3) radiation plate, (4) temperature measuring system, (5) constant source of heating current, and (6) constant temperature room.

(1) Fiber Case

The fiber case was made of hard-pressed fiber board as described above.

(2a) Heater Plate for Testing up to 1400°C

The central heater, 4 by 4 inches, was made by winding an Alundum plate ($3^3/_4$ by $3^3/_4$ by $^1/_8$ inch) with about 20 feet of Bishop's No. 803 platinum tantalum alloy heater wire 0.020 inch in diameter. The ends were brought out at adjacent corners. When diagonally wound, the direction of the wire is at right angles top and bottom of the winding and the turns lie about $^1/_8$ inch apart. Figure 9 shows a template partly wound.

The core with its platinum-alloy resistor is faced on each side with an Alundum plate (4 by 4 by $^1/_4$ inch) cemented by means of an Alundum cement,[2] taking precautions to flood the winding

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* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934, as part of the Symposium on Heat Transfer through Refractories and Insulation in Industrial Furnaces.

Received December 21, 1934.

For other papers in this series, reference is made to the following published papers:

(1) J. D. Keller, "Application of Insulating Materials to Industrial Furnaces," *Jour. Amer. Ceram. Soc.*, **17** [4], 77–87 (1934).

(2) G. W. Wilkes, "Thermal Conductivity of Refractories," *ibid.*, **17** [6], 173–77 (1934).

(3) C. E. Weinland, "Measuring Thermal Conductivity at Furnace Temperatures," *ibid.*, **17** [7], 194–202 (1934).

(4) H. W. Russell, "Principles of Heat Flow in Porous Insulators," *ibid.*, **18** [1], 1–5 (1935).

(5) J. L. Finck, "An Apparatus for Measuring the Thermal Conductivity of Refractories at High Temperatures," *ibid.*, **18** [1], 6–12 (1935).

(6) R. H. Heilman and R. S. Bradley, "Thermal Conductivity of Refractories under Operating Conditions," *ibid.*, **18** [2], 43–48 (1935).

[1] T. H. Blakeley and J. W. Cobb, "Apparatus for Testing Heat-Insulating Brick," *Jour. Soc. Chem. Ind.*, **51** [11], 83–89 (1932).

[2] From Norton Company.

completely with the cement and to eliminate air pockets.

The formula for the cement is

RA	562	45% by weight
	563	45
	305	10

Water sufficient to make a heavy slip consistency is added.

The cement is also plastered on the edges to fill them flush with the 4- by 4-inch cover plates. After thorough drying the plate is fired, preferably in a sagger, to about 1100°C to permit further handling without danger of separating the plates.

Heavy leads (0.040 inch) of No. 803 alloy are set in holes drilled in one of the Alundum cover plates about $^1/_2$ inch from the corners near the protruding ends of the heater wire, and grooves are cut in the cement to carry the heater wire to the leads to which they are welded very close to the edge of the plate. The wire is next buried in Alundum cement mix and the holes anchoring the heavy leads are painted with the cement.

The heavy leads are bent down sharply at right angles to the plate and pass through a tile made of insulating brick, 8 by 8 by 1 inch, on the center of which the central heater is cemented with the mixture given above.

The guard heater is wound in like manner on a square of Alundum, 8 by 8 inches, with an opening $4^1/_4$ by $4^1/_4$ inches in the center. The tile is $^1/_8$ inch thick and after winding is faced on each side with an Alundum tile of the same size as the core but $^1/_4$ inch thick. The tile are cemented with the Alundum cement mixture and fired to 1100°C to permit further assembly. The leads are then attached, arranging the winding to allow the leads to come out in the $^1/_8$-inch gap between the heaters. The leads are bent down as in the case of the central heater and the guard heater is then spaced on the supporting tile of insulating brick so that the $^1/_8$-inch gap between the heaters is evenly spaced.

The heaters are cemented to the tile with the Alundum cement mixture after which the projecting leads are again bent at right angles to bring them out toward the side of the box. A second insulating brick tile is cemented to the supporting tile as protection for the leads and for added insulation below.

The entire plate assembly is then fired to 1400°C and small grooves are cut in the working face of the plate with a diamond scribing tool $^1/_8$ inch on each side of the gap at two opposite sides of the center heater so that platinum-platinrhodium couples may be laid in the grooves and connected differentially for the purpose of matching the temperature of the central heater with the guard. An additional thermocouple groove is cut across the plate parallel with the first grooves and $^1/_8$ inch off the center line for a couple which is used for quickly determining the temperature of the central heater.

The couples can all be laid in their grooves and stretched by means of small lead sinkers hung

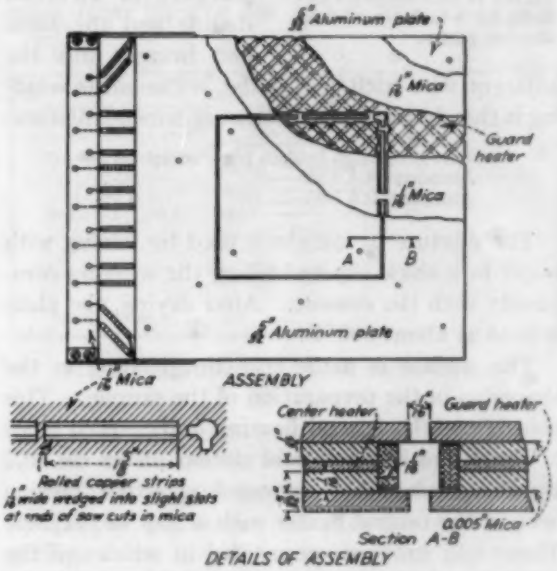

FIG. 1.—Assembly of 4-inch guarded radiation plates.

low enough in the box to be below the melting point of lead.

NOTE: It is important that every portion of the heater wire be buried in Alundum cement for otherwise the wire may overheat locally and burn out. If the surface of the heater plate is not plane, a light cut is taken with a tool post grinder held in a shaper.

The heavy leads are bent down one inch from the ends to dip into mercury cups located on the side of the box where contact is made with the source of power through appropriate switches, rheostat, and ammeter.

The heater plate rests on a column of insulating block and brick to bring it to the proper level.

(2b) Hot Plate with Base Metal Resistor

For temperatures not over 1000°C hot side, a much cheaper guarded hot plate was constructed.

The refractory base is a portion of the side-wall refractory.[1] The side-wall refractory measured 4 by 12 inches and was cut into three equal-size pieces with a hack-saw. This formed the central section, 4 by 4 inches. Appropriate pieces were chipped out of the fluted section to allow a spiral-wound resistor of Chromel to be slipped into place. The lead portion is twisted double and the loose end brazed into the adjacent wire with gold solder. The entire winding is then buried in the following cement mixture:

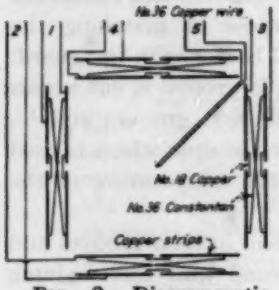

FIG. 2.—Diagrammatic sketch of thermocouple circuits for 4-inch guarded radiation plates.

Fine grog from broken plate scrap	50%
Alundum RA 355	35%
Alundum RA 305	15%

The mixture by weight is used by mixing with water to a thick slip and filling the winding completely with the cement. After drying, the plate is fired at about 980°C.

The surface is made true by grinding in the shaper as in the preparation of the sample. This constitutes the central heating unit.

The guard is made from similar pieces cut $6^1/_8$ by $1^7/_8$ inches and arranged swastika fashion around the central heater with a gap of $^1/_4$ inch. These four units are connected in series and the leads are brought out long enough to reach the side of the box where they dip into mercury wells. A sketch showing the arrangement of parts of this plate is given in Fig. 5.

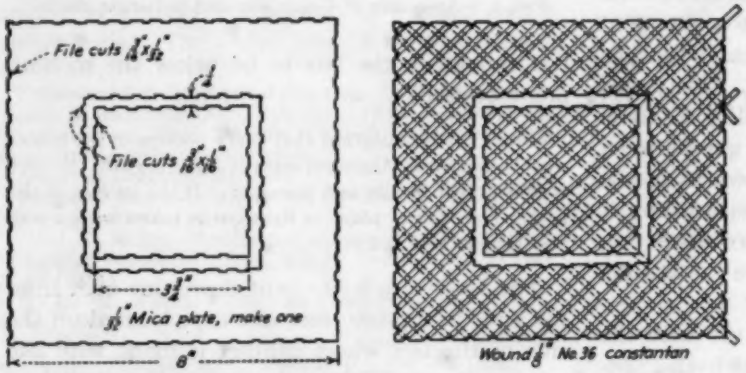

FIG. 3.—Heating grids for 4-inch guarded radiation plate.

[1] Made for the Electric Heating Apparatus Company furnaces.

The guard units and central heater are mounted on a tile of insulating brick, 8 by 8 by 1 inch, and cemented with the same cement as used to fill up the resistor channels.

Fine grooves are cut with the diamond scribing tool for guard matching couples and center couple as in the case of the high-temperature plate with platinum heaters.

It is best to fire the entire assembly to 980°C before use to insure rigid setting of the cement.

With this type plate, No. 28 B. & S. gage Chromel/Alumel thermocouples can be used, thus reducing the expense of both construction and operation since the base-metal couples are more rugged.

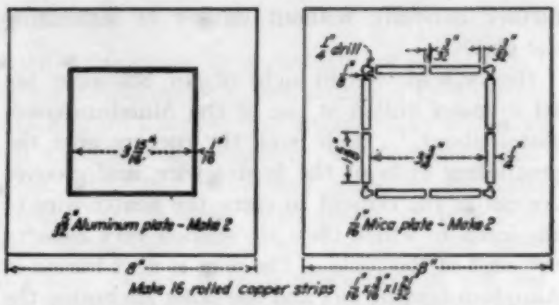

FIG. 4.—Aluminum and mica plates; 4-inch guarded radiation plate.

(3) Radiation Plate

The radiation plate is identical in principle and in some detail with the 4-inch guarded hot plate with the 2-inch guard ring designed at the Bureau of Standards for the purpose of measuring thermal conductivity of low-temperature insulating materials.

The plate consists of a 4-inch central area and a 2-inch guard ring, each provided with individual heaters of constantan. Figure 10 shows the completed plate. The gap between the heaters has copper strips inserted at the sides of the gaps bridged by constantan wire to provide differential couples for the purpose of matching the temperature of the guard to that of the center. Several sketches (Figs. 1 to 4, inclusive) show the details of this equipment.

The chief differences between this equipment and that designed at the Bureau of Standards are

(*a*) that the insulating material used is composition mica with an inorganic binder, (*b*) the use of brazed connections on all couples in the plate instead of soldered connections, and (*c*) the use of aluminum instead of copper for the confining plates.

In the early work with radiation plates as a means of measuring heat flow, a flat black surface of paint was used on the plates. With the use of the radiation plate at higher temperatures it became necessary to secure a more durable surface. It was finally decided to use aluminum plates,[4] with an electrolytically deposited coating which has an emissivity of 90% at 100°C. This coating does not check, peel, or crack and is easily cleaned and very durable, thus doing away at once with the necessity of frequently recoating the radiating surfaces. The plates were likewise made $^{5}/_{32}$ inch thick to allow for the lower thermal conductivity and lower tensile strength of the material. A further difference lies in the point that all thermocouple leads were brought out of the plate instead of having some connected internally.

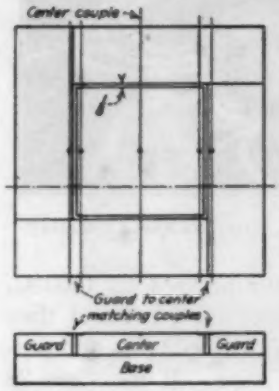

FIG. 5.—Guarded hot plate for 1000°C.

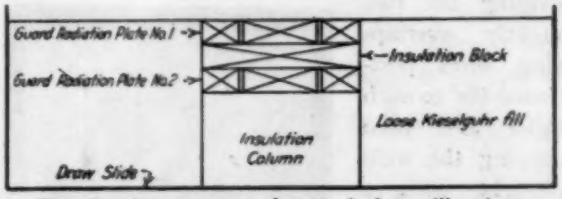

FIG. 6.—Arrangement of parts during calibration.

(4) Temperature Measuring

The measuring system should be a Leeds & Northrup Type K potentiometer or its equivalent. An iced thermos bottle is used for all cold ends.

(5) Power Source

The source of power can be anything over 32 volts alternating or direct current since the plate wound as above is practically noninductive. The power, however, must be very steady or ballast tubes must be used to smooth out fluctuations.

(6) Constant Temperature Room

The apparatus is mounted in the center of the room, 8 by 8 by 7 feet high. The room is cooled by means of four cooling units from household refrigerators which are added one at a time as occasion requires and kept running continuously. The temperature is reduced by this means somewhat under the desired regulating point and regulation is obtained by means of a 500-watt strip heater controlled by a thermostat. The swing from high to low is less than 1°C. The room temperature is maintained at about 25°C. The air in the room is circulated by means of a small fan, nonoscillating, located on the floor. By proper positioning of this fan an efficient mixing of the air in the room takes place with practically no circulation across the radiation plate in the center of the room. The amount of circulation used is not critical but should be fairly constant. The operation of the thermostat is monitored by an operation recorder which serves to show the relative lengths of time of the on- and off-periods.

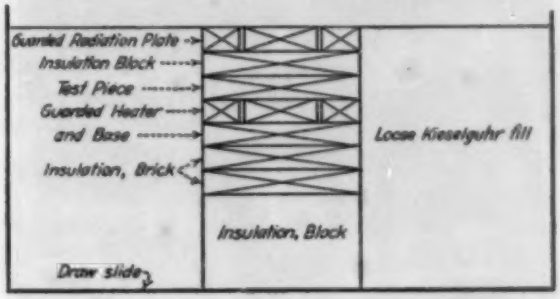

FIG. 7.—Arrangement of parts during testing.

III. Preparation and Set-up of the Test Piece and Guard Pieces

The test piece is cut from one-half of a nine-inch straight brick by grinding all surfaces by means of a tool post grinder held in a shaper. The final size is 4 by 4 by 1 inch. The guard pieces, four in number, are cut 6 by 2 by 1 inch and are placed around the test piece in the form of a swastika. A fine groove is cut across each 4- by 4-inch face with a diamond scribing tool to lay in the 0.005-inch bare platinum thermocouple wire.

[4] Coated by the Aluminum Company of America with Alumilite No. 204 Coating.

The thermocouple wires are cemented in these positions in the grooves by means of a cement made of 1/2-second nitrocellulose.

This dries quickly, readily burns out without

FIG. 8.—General view of apparatus ready for test.

trace, and assures the operator of exactly positioning the couples during the set-up.

The test piece and guard pieces are laid, with the couples, directly on the face of the hot plate.

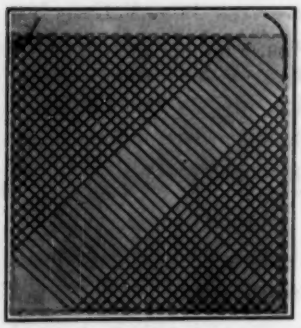

FIG. 9.—Four- by 4-inch template showing manner of winding the platinum alloy resistor.

In order to get high mean temperatures of refractories, additional insulation is necessary to prevent the radiation plate from getting hotter than about 300°C.

A 4- by 4- by 1-inch block of insulating material of the softer varieties is laid on the test piece together with appropriate guard pieces. This block must be capable of withstanding 980°C hot face without checking, cracking, or shrinking.

The radiation plate is laid on top of the entire pile, being so positioned that the top surface of the plate is about 1/2 inch below the top of the case. A cover piece, 1/2 inch thick, is placed on the radiation plate during the filling process. The entire space between the tile and the case is then

FIG. 10.—Guarded radiation plate; complete assembly.

filled with loose kieselguhr prefired to 1400°C, levelled off with the top of the case, and then pressed down with a board 1/2 inch thick and provided with handles and stops. It measures 28 by 10 by 1/2 inch.

A thermocouple provided with a radiation shield is located about two feet from the plate for the purpose of getting the temperature of the ambient air.

IV. Notes on Thermocouple Welding

Thermocouples of platinum *vs.* 90% platinum, 10% rhodium (0.005 inch) are made by arc welding the two slightly overlapping wires positioned 90° to each other and then tapping the weld straight with a light mallet. There is practically no bead formed by this procedure. A special jig, which has been in use for a number of years and has proved very satisfactory, is used for welding small wires. It is made by cutting in two parts one-half of a small removable pin hinge, the lower portion of which is soldered to the end of a small metal plate for a base.

FIG. 11.—Star silica skiagraph showing defect near edge of test piece.

The halves of two spring clothes-pins including the springs are fastened to the base so that the nose portion of the wooden pins rests on the split portion of the hinge to form a simple clamp. A rubber band placed in the bight of the hinge

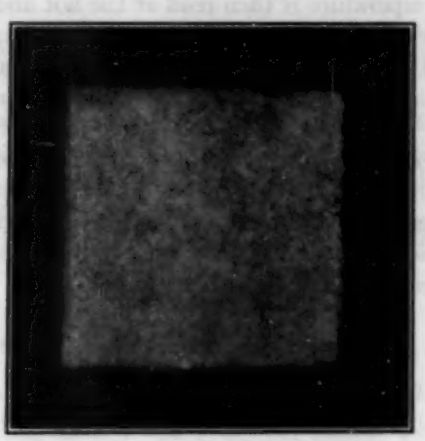

FIG. 12.—Mexko brick skiagraph.

serves as a spring to raise the half of the hinge for insertion of the wires to be welded. Figure 13 shows a view of the jig.

A small carbon arc pencil connected to a carbon compression rheostat, lamp bank, or any of the usual methods for controlling the current completes the circuit through a lead soldered to the metal base of the jig. The current used is easily adjusted for the wire being welded by striking a test spark on the metal base. The source of current may be any type as long as it is capable of

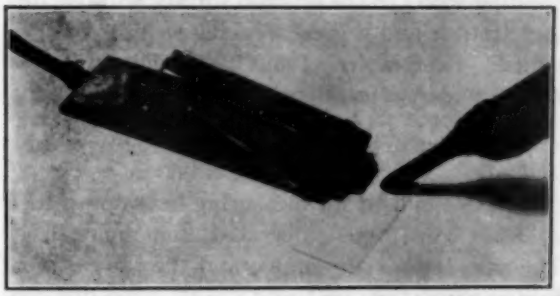

FIG. 13.—Thermocouple welding jig.

making a sufficient spark; 110 volts alternating current is usually at hand.

A microscope slide is placed under the edge of the hinge to allow the electrode to slip over it in approaching the point to be welded. Figure 14 shows a close-up of the jig in use.

One of the wires is placed in each half of the hinge jig at an angle of 90° or more with the ends overlapping about the thickness of the wire and touching.

Half-shade colored glasses are used and the weld can be watched through a jewelers' magnifying glass if the operation is strongly illuminated. But little experience is necessary and wires of 14–40 B. & S. gage can be easily handled.

The weld can then be hammered straight and the wire annealed by passing a suitable current while the ends are held in the jig and clipped to the electrode with a spring clothes-pin.

V. Calibration of the Radiation Plate

Two guarded radiation plates were made up exactly alike and placed in the apparatus, one below the other, separated by one inch of insulating block (Fig. 6). The upper radiation plate center was heated to a desired point and its guard was heated so that the guard matched the central area in temperature. The bottom radiation plate was likewise heated so that the center section matched the center section of the plate immediately above it and its guard was likewise heated to match its center. The center of the top radiation plate is exactly matched in temperature at all sides and below, making it impossible for heat to be lost except upward to the air. The voltage and amperage necessary to heat the plate to this point was measured by a Leeds & Northrup standard precision shunt volt box and type K potentiometer. The excess temperature of the plate over ambient air was also measured and a series of points obtained in this manner up to the highest point desired, about 300°C. Since constantan wire was used in winding the heaters no appreciable change in resistance is encountered and it becomes possible to measure the wattage by means of the formula I^2R. This point was checked by measuring the resistance at the connection plate and checking the I^2R loss against the VA readings; they agreed to within 1%.

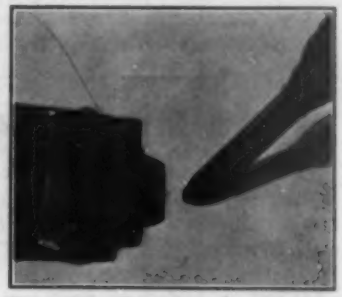

FIG. 14.—Close-up of operating position of welding jig.

To obtain the exact resistance of the center unit it became necessary to apply a correction for the length of heater wire from the connection

strip to the center of the heater. This was done by measuring the resistance of ten feet of the identical wire used in winding the heater and subtracting the resistance due to the additional length of heater wire in the circuit from the central heating plate to the connection bar. A calibration curve was then drawn after the wattage used in the several tests was calculated to calories per second per square centimeter, using as abscissa excess temperature of plate over ambient air expressed in millivolts of the copper constantan

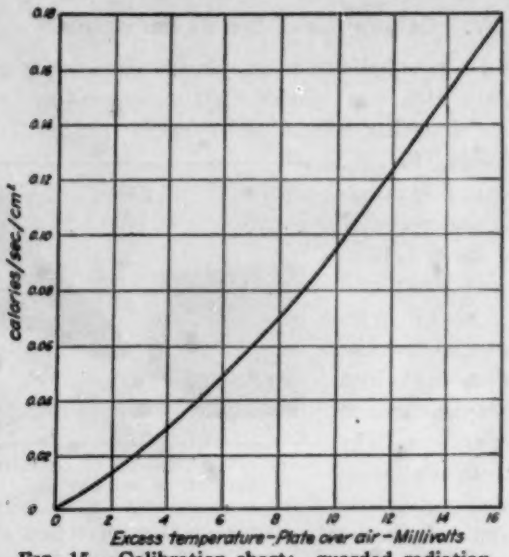

FIG. 15.—Calibration chart: guarded radiation plate No. 1.

thermocouples used. Figure 15 shows the calibration chart obtained.

By the above procedure it is at once seen that the calibration of the radiation plate is direct and it is unnecessary to know the emissivity of the radiating surface. The variation of the convection factor is very slight when the above precautions are taken and observed. The radiation plate is used in exactly the same position as when it was calibrated, the only difference being that the central heater is heated by means of the heat flow through the sample, and when a certain excess temperature is reached the rate of heat flow is at once known by reference to the calibration curve. Since a thermostated room is used in the calibration and during the tests it becomes necessary to draw but one curve for the existing conditions.

VI. Testing Procedure and Calculation

The central heater and guard of the high-temperature plate are raised to any desired point matching the temperature of the radiation plate center with its guard and maintaining the conditions until the steady state is reached. The arrangement is shown in Fig. 7. Starting from cold, this point can be obtained in about 24 hours. The temperature is then read at the hot and cold surface of the test piece and the excess temperature of the plate over the ambient air. Knowing the thickness, the temperature gradient is calculated. Referring to the calibration chart the excess temperature of plate over air gives the heat flow directly. Heat flow divided by temperature gradient gives the thermal conductivity in centimeter-gram-second units. Multiplying by 2903 gives the results in English units.

VII. Notes on Preparation of Test Pieces

In the tests on Star silica and Mexko brick, no difficulty was found in cutting the Star silica to test-piece dimensions, but the Mexko brick had to be handled somewhat differently due to the fact that the surface tore out under the grinding wheel leaving pock marks $^1/_8$ inch deep.

A grog was made of pieces of the same brick (about 10-mesh) and was mixed with 10% of its weight of kaolin and wetted to a soft mush with sodium silicate solution cut to half strength with water.

This mixture was plastered on both 4- by 4-inch surfaces, dried, and fired in a sagger to 1200°C.

The surface could then be cut down with the grinding wheel to the original surface without further trouble and a good working surface was obtained. Skiagraphs of both Mexko and Star silica are shown in Figs. 11 and 12.

VIII. Summary

A device is used for measuring heat flow which is easily constructed, operated, and maintained. The calculations are simple and the laws of heat flow on which they are based are all given due consideration in the primary calibration of the radiation plate which is by direct measurement.

Only the usual physical standards as maintained in most physical laboratories are necessary.

By the use of ballast tubes the current in the center heater can be set and the guards balanced by means of the differential couples.

ARMSTRONG CORK COMPANY
CENTRAL TECHNICAL LABORATORY
LANCASTER, PA.

CERAMIC ABSTRACTS[1]

Compiled by the

AMERICAN CERAMIC SOCIETY

Ross C. Purdy, Editor

Abstracters: A. Ally, J. B. Austin, A. A. Ayars, R. Barta, M. H. Berns, L. T. Brownmiller, P. P. Budnikoff, W. M. Cohn, J. L. Gallup, Max Hartenheim, F. G. Heck, R. A. Heindl, E. B. Hewitt, G. M. Hutt, S. Kondo, M. V. Condoide, A. Kuechler, J. T. Littleton, S. I. Perkal, J. G. Phillips, R. H. H. Pierce, Jr., W. E. Rice, M. C. Shaw, G. R. Shelton, H. H. Stephenson, H. Türk, E. J. Vachuska, H. F. Vieweg.

Vol. 14 **April, 1935** **No. 4**

Abrasives

PATENTS

Abrading machine. R. F. Knight (United Shoe Machinery Corp.). U. S. 1,987,832, Jan. 15, 1935. William Scrimgeour. U. S. 1,988,577 and 1,988,578, Jan. 22, 1935.

Abrading material and process for preparing. Theodor Pohl and Josef Schneider. U. S. 1,986,849, Jan. 8, 1935. As an article of manufacture, a grinding body of cellular structure consists of abrading and binding materials and has hollow spaces uniformly interspersed throughout; the hollow spaces are larger than the grains of the abrading material used.

Abrasive article and method of making. G. H. Davis (Carborundum Co.). U. S. 1,989,742, Feb. 5, 1935.

Abrasive-coated sheets. W. J. Tennant (Durex Corp.). Brit. 422,857, Jan. 30, 1935.

Abrasive smoothing or polishing cloths and method of manufacturing. Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler. Brit. 420,912, Dec. 28, 1934.

Abrasive surfacing disk. J. A. Malcolm (Julius S. Neale). U. S. 1,988,874, Jan. 22, 1935.

Adhesive for coating, penetrating, sizing, priming, or waterproofing a base or backing and for bonding grit to a base or backing to form a flexible waterproof abrasive. A. H. Stevens (Minnesota Mining & Mfg. Co.). Brit. 421,394, Jan. 2, 1935.

Apparatus for grinding discontinuous segmental surfaces. F. A. Ward (Gear Grinding Machine Co.). U. S. 1,987,222, Jan. 8, 1935.

Apparatus for grinding and lapping cylindrical members. C. R. Heim. U. S. 1,987,850, Jan. 15, 1935.

Ceramic bonded abrasive article. L. H. Milligan and David Armitage (Norton Co.). U. S. 1,987,861, Jan. 15, 1935. An abrasive article comprises refractory granular material and a ceramic silicate bond that includes at least 1% of phosphoric oxide and alumina in its chemical composition; the bond has been developed by heat.

Cylinder grinding tool. H. W. Zimmerman (Automotive Maintenance Machinery Co.). U. S. 1,987,457, Jan. 8, 1935.

Device for dressing profiled grinding wheels. Hermann Godziewski (Herbert Lindner G.m.b.H.). U. S. 1,988,895, Jan. 22, 1935.

Die lapping machine. P. J. Helmstadter (Firth-Stirling Steel Co.). U. S. 1,990,074, Feb. 5, 1935.

Edge grinder. A. J. Holman. U. S. 1,990,488, Feb. 12, 1935.

Expansible honing tool. L. W. Johnson. U. S. 1,991,220, Feb. 12, 1935.

Feeding device for centerless grinders. K. L. Herrmann. U. S. 1,989,923, Feb. 5, 1935.

Flexible abrasive articles, sandpaper, etc., and method of making. A. H. Stevens (Minnesota Mining & Mfg. Co.). Brit. 421,107, Dec. 28, 1934, and Brit. 421,331 and 421,399, Jan. 2, 1935.

Grinder dressing machine. F. O. Albertson (Albertson & Co., Inc.). U. S. 1,987,812, Jan. 15, 1935.

Grinding or abrading machines. W. W. Triggs (Norton Co.). Brit. 421,568, Jan. 9, 1935.

Grinding, etc., machine tools. A. Herbert and A. H. Lloyd. Brit. 421,005, Dec. 28, 1934.

Grinding machines. Norton Co. Brit. 422,160, Jan. 16, 1935.

Honing tool. F. M. Kern (Micromatic Hone Corp.). U. S. 1,990,331, Feb. 5, 1935.

Manufacture of bonded abrasive articles. Carborundum Co., Ltd. Brit. 421,651, Jan. 9, 1935.

Manufacture of open-spaced abrasive fabrics. C. E. Wooddell (Carborundum Co.). U. S. 1,988,065, Jan. 15, 1935.

Manufacture of rubber-bonded abrasive products. J. N. Kuzmick and J. A. Lange (Raybestos-Manhattan, Inc.). U. S. 1,990,737, Feb. 12, 1935. The method of making an abrasive product consists in incorporating naphthalene with rubber, subjecting them to heat at relatively high temperatures and producing thereby the liquefaction of the rubber, and in mixing the liquefied rubber with abrasive particles, synthetic resin, and a vulcanizing agent.

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

The abbreviation (*R.C.C.S.*) at the end of an abstract indicates that it was obtained from the *Reports of the Czechoslovakian Ceramic Society.*

Method and means for dressing revolving grinding wheels. H. F. ATKINS. Brit. 422,227, Jan. 23, 1935.

Mountings for thin abrasive wheels. INDUSTRIES OF AMERICA, INC. Brit. 422,740, Jan. 30, 1935.

Pinhole grinder mandrel. JOSEPH SUNNEN. U. S. 1,989,831, Feb. 5, 1935.

Polishing, abrading, etc., devices. R. BOSCH AKT.-GES. Brit. 421,912, Jan. 16, 1935.

Portable grinding machine. A. W. MALL. U. S. 1,987,837, Jan. 15, 1935.

Process of producing grinding bodies. THEODOR POHL AND JOSEF SCHNEIDER (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). U. S. 1,986,850, Jan. 8, 1935.

Rail grinder. C. H. PECK (Ingersoll-Rand Co.). U. S. 1,988,138, Jan. 15, 1935.

Track grinder. H. H. TALBOYS (Nordberg Mfg. Co.). U. S. 1,991,234, Feb. 12, 1935.

Valve seat grinding machine. F. O. ALBERTSON (Albertson & Co., Inc.). U. S. 1,989,905, Feb. 5, 1935.

Waterproof abrasive and method of making. F. J. CRUPI (Behr-Manning Corp.). U. S. 1,987,467, Jan. 8, 1935.

Art and Archeology

Artist in industry. W. GAUNT. Presented at meeting of North Staffordshire Branch, Soc. of Industrial Artists, Nov., 1934, Hanley, England. *Pottery Gaz.*, **60** [691], 81–86 (1935).—A designer may grow up in a particular industry or be recruited from outside. Pottery designing consists of more than merely drawing two-dimensional designs. The differences are pointed out. Contacts with other artists aid the designer in producing better work. E.J.V.

British art in British pottery. GORDON M. FORSYTH. Presented at meeting of Royal Soc. of Arts, Nov., 1934, Adelphia, England. *Pottery Gaz.*, **60** [691], 73–80 (1935). The qualities of pottery, craftsmanship in its production, and art applied to mass production are discussed. The English style in pottery, clay decoration, and modern methods of mass production are presented. Illustrated. E.J.V.

Ceramics: Teaching the buyer and creation of models. M. BERTHON. *Céram., Verrerie, Email.*, **2** [4], 161–64 (1934).—B. cites the lack of ceramic knowledge of the public and stresses the need for education along these lines. The creation of models should be left to both the workman and the artist. M.H.B.

Maxwell triangle yielding uniform chromaticity scales. DEANE B. JUDD. *Jour. Research Nat. Bur. Stand.*, **14** [1], 41–57 (1935); R.P. 756. Price 5¢.—A colorimetric coördinate system's Maxwell triangle has the following useful property: the length of any line on it is a close measure of the chromaticity difference between the stimuli represented at the extremes of the line. An important application of this coördinate system is its use in finding from any series of colors the one most resembling a neighboring color of the same brilliance. R.A.H.

Old English glass. No. 55. Glass salts. FRANCIS BUCKLEY. *Glass*, **11** [9], 344 (1934).—The development of the old English salts, similar to the modern glass salt shaker, is sketched. **No. 56. Table set.** *Ibid.*, **11** [10], 388 (1934).—Old Anglo-Venetian lead glass is described. Two rare specimens of this glass are shown. For Nos. 53–54 see *Ceram. Abs.*, **14** [1], 9 (1935). M.C.S.

Pottery manufacture: historical sketch. ANON. *Clay Prod. Jour. Australia*, **1** [4], 23 (1934).—Important dates from the Greek vases of 500 B.C. to the parian statuary of 1850 A.D. are given. H.H.S.

BOOKS

Antique Ceramic Firing Furnaces. V. F. GAIDUKEVICH. Eightieth issue of publications of State Academy of History of Material Culture. State Social-Economic Pub. House, Moscow-Leningrad, 1934. 116 pp. Price 2 R. 20 k. The description is based on excavations carried out in Kerch and Fanagoriya in 1929 and 1931. Illustrated. S. I. PERKAL

Conquest of ugliness: the place of art in industry. Edited by J. DE LA VALETTE. Methuen, London, 1935. Reviewed in advance in *Times* (London), Nov. 20, 1934. H.H.S.

PATENTS

Designs for:

Bottle. F. E. BALL (Ball Bros. Co.). U. S. 94,461, Feb. 5, 1935. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 94,384 and 94,385, Jan. 22, 1935. G. T. GIBSON (Guy T. Gibson, Inc.). U. S. 94,546, Feb. 12, 1935. W. R. LEACH (Carr-Lowrey Glass Co.). U. S. 94,498, Feb. 5, 1935. T. J. PIAZZOLI (Capstan Glass Co.). U. S. 94,357, Jan. 15, 1935. C. M. PLOCHMAN (Plochman & Harrison). U. S. 94,358, Jan. 15, 1935. J. S. STEELMAN (Whitall Tatum Co.). U. S. 94,393, Jan. 22, 1935, and U. S. 94,573 to 94,575, Feb. 12, 1935. RENÉ TRICARD (Lentheric, Inc.). U. S. 94,397, Jan. 22, 1935. E. G. WESTLAKE (Marshall Field & Co.). U. S. 94,398, Jan. 22, 1935.

Casserole holder. W. D. TEAGUE (Corning Glass Works). U. S. 94,577 to 94,580, Feb. 12, 1935.

Cocktail-shaker top. FINLEY WILLIAMS (Fostoria Glass Co.). U. S. 94,373, Jan. 15, 1935.

Drinking glass. C. M. MARQUOT. U. S. 94,553, Feb. 12, 1935.

Flask. F. E. BALL (Ball Bros. Co.). U. S. 94,462, Feb. 5, 1935.

Glass bottle. L. J. KIHN (J. T. & A. Hamilton Co.). U. S. 94,496, Feb. 5, 1935.

Jug. A. J. CALPHA (Olean Glass Co.). U. S. 94,333 and 94,334, Jan. 15, 1935.

Range. S. H. HOBSON (Geo. D. Roper Corp.). U. S. 94,485, Feb. 5, 1935.

Range having lighting unit, clock, and condiment holder. ORRIN HOFFERBERT (Malleable Iron Range Co.). U. S. 94,486, Feb. 5, 1935.

Method and apparatus for decorating ceramic ware. SOLAR LABORATORIES. Brit. 421,004, Dec. 28, 1934.

Cements

Action of sulfides contained in blast-furnace slag in cement mortar and concrete. H. BURCHARTZ AND E. DEISS. *Arch. Eisenhüttenwesen*, **8**, 181–86 (1934).—Sulfides will not form sulfate in mortar and concrete containing blast-furnace slag, even under the most unfavorable conditions. The results were identical for coarse pieces of slag and for granulated slag. W.M.C.

Compressive strength, Young's modulus of elasticity, and Poisson's ratio of Keene's cement. ANON. *Nat. Bur. Stand. Tech. News Bull.*, No. 212, p. 127 (Dec., 1934).—Measurements were made of the lateral and longitudinal deformations under a compressive load on 4 prisms of cement. The wet mix contained 39% water by weight of Keene's cement. The prisms were 4 x 4 x 8 in. and were cured 21 days at 37.7°C. The average values of the secant modulus of elasticity, Poisson's ratio, and the compressive strength were:

Compressive stress (lb./in.²)	Modulus of elasticity (lb./in.² × 1,000,000)	Poisson's ratio
500	2.03	0.25
1000	1.99	0.25
1500	1.95	0.26
2000	1.89	0.26
2500	1.84	0.27
3125	1.68	0.29

Compressive strength 4420 lb./in.². R.A.H.

Constitution of clinkers of Portland cement. B. TAVASCI. *Giorn. chim. ind. applicata*, **16** [11], 538–52 (1934).—Portland cement clinkers have been found to contain generally five constituents of the following compositions: alite, $3CaO \cdot SiO_2$; belite, $2CaO \cdot SiO_2$, in which an α, β, and an unstable phase are distinguished; celite, forming an intimate aggregate of two constituents of which one (celite *a*) is represented by $3CaO \cdot Al_2O_3$, and the other (celite *b*), by $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$; but often $2CaO \cdot Fe_2O_3$ only is found. A frequent constituent is pure CaO. The properties and metallographical aspects of these constituents are described in detail. 16 references. M.H.

Cylinder *versus* cube *versus* prism as compression test specimen for mortars. HERBERT J. GILKEY. *A.S.T.M. Bull.*, No. 71, p. 5 (Dec., 1934).—It is recommended, after an analysis of the problem, that the 2 x 2 x 4-in. mortar prism be definitely adopted as the standard test specimen for mortars, replacing the 2-in. cube and the 2 x 4-in. cylinder. It is suggested that steps be taken to specify the essential features of molds which will produce satisfactory specimens and that no immediate change be made in the compression specimen for concrete, but that the matter be studied with a view to the substitution of square prisms for the cylinders now employed. R.A.H.

Hydrates of aluminates, sulfoaluminate, and chloraluminate of calcium. J. LEFOL. *Compt. rend.*, **199** [24], 1412–14 (1934).—By thermal dehydration, several aluminates and double salts of calcium were obtained. $Al_2O_3 \cdot 4CaO \cdot 12H_2O$ only can be dehydrated and transforms into a hydrate with $8H_2O$; the process is reversible. $Al_2O_3 \cdot 3CaO \cdot 6H_2O$ is the most stable of all hydrates investigated. $Al_2O_3 \cdot 2CaO \cdot 8H_2O$ absorbs or gives up water according to the vapor tension of its surroundings. $Al_2O_3 \cdot 3CaO \cdot 3SO_4Ca \cdot 30H_2O$ and $Al_2O_3 \cdot 3CaO \cdot CaCl_2 \cdot 10H_2O$ are stable hydrates which dissociate only under low pressure to form a hydrate with $7H_2O$ for the former and $6H_2O$ for the latter. M.H.

Hydrates of bicalcium aluminates. S. RENATO. *Gass. chim. ital.*, **64** [10], 719–34 (1934).—Bicalcium aluminate, $2CaO \cdot Al_2O_3$, forms numerous hydrates; those with 1 to 11 H_2O are investigated and their mode of preparation, properties, and constitution are described. 12 references. M.H.

PATENTS

Manufacture of cementitious materials. CEMENT PROCESS CORP. Brit. 422,238, Jan. 23, 1935.

Process for manufacture of cement. H. E. POTTS (Soc. des Ciments du Congo). Brit. 422,359, Jan. 23, 1935.

Process for manufacture of white Portland cement in a rotary kiln. JEAN MERCELIS. U. S. 1,987,485, Jan. 8, 1935. A process for the manufacture of white Portland cement in a rotary kiln employs raw materials poor in Fe oxide and consists in treating the clinker, while still hot after clinkering, with acids or substances yielding acids at high temperature.

Enamels

Adherence of sheet iron enamel. L. VIELHABER. *Emaillerie*, **2** [5], 5–6 (1934); abstracted in *Emailwaren-Ind.*, **11** [40], 336 (1934).—The latest researches of Heimes (*Ceram. Abs.*, **13** [11], 284 (1934)), King (*ibid.*, **13** [8], 201 (1934)), and Dietzel (*ibid.*, **14** [1], 3 (1935)) on the adherence of sheet iron enamel are discussed. M.V.C.

Does cost of pickle room control prevent its practice? ANON. *Amer. Enameler*, **7** [7], 3–4 (1934).—The use of pickle pills for the determination of various solutions *vs.* the use of titrating outfits and solutions is presented. The complete cost of the methods referred to and the average monthly costs of economical mill room control, one of the most important factors in enameling plant control, are given. K.H.T.

Electric welding in the enamel industry. P. W. FASSLER. *Enamelist*, **12** [5], 5–6 (1935).—F. traces the development of electric welding as applied to the German enamel industry from its beginning about 1908. Illustrated. E.J.V.

Furnace firing conditions checked. J. T. IRWIN. *Enamelist*, **12** [4], 18–19 (1935).—To check the time-temperature cycle of both the ware and the atmosphere surrounding a piece of ware as it traveled through a continuous furnace, a 100-ft. thermocouple insulated by porcelain bead insulators was used. The thermocouple head, fastened to a ware hanger on the furnace chain, was allowed to pass through the furnace while potentiometer readings were taken for every 3 ft. of travel through the

effective furnace length. To check the ware temperature the thermocouple was spot-welded to the center of a large sheet iron panel which was dipped in ground coat and then put through the furnace as a regular production item, the temperatures again being checked by potentiometer readings for every 3 ft. of travel. Plotting the ware temperature curve against the furnace-atmosphere curve shows very clearly just how much lag, if any, there is between ware and furnace atmosphere at all points in the furnace. E.J.V.

Glass enameled steel. E. E. GEISINGER. *Mech. World*, **97** [2506], 35 (1935).—Uses for glass-enameled steel in storage equipment and dwelling and store fronts are discussed. The process and equipment used in enameling steel are described. E.J.V.

Microscope in enamel research and control. ANON. *Amer. Enameler*, **7** [8], 3 (1934).—The application of petrographic and metallographic microscopes to the enameling industry is discussed and examples of their uses are given. K.H.T.

Pickle room well ventilated. ANON. *Enamelist*, **12** [5], 15 (1935).—Illustrated. E.J.V.

Pitting and crazing of ground coat and blistering of black edge in sheet-iron enamels. W. C. CUMMINGS. *Enamelist*, **12** [5], 7 (1935).—Pitting and crazing of sheet iron ground-coat enamels and blistering of black-edge enamels applied on the unfired ground coat were encountered when an oil-fired furnace was put into use. Tests made using an electric furnace for firing the ground coat resulted in no remedy. On changing the drier from the use of hot air drawn around the oil furnace stack to steam coil heating the trouble of pitting was eliminated. Evidently products of combustion had leaked through the stack and were affecting the pickled ware and the undried dipped ground-coated ware to cause the pitting and blistering. E.J.V.

Porcelain enamel finish. J. M. SEASHOLTZ & SONS, INC. *Amer. Enameler*, **7** [8], 6 (1934).—Snowflake, a new finish producing a crystalline effect at a minimum cost, is described. K.H.T.

Porcelain enamel service stations adopted by leading oil companies. HARRY E. MARTIN. *Enamelist*, **12** [5], 13–14 (1935).—Illustrated. E.J.V.

Porcelain enamel steel fence. ANON. *Enamelist*, **12** [5], 26–27 (1935).—Illustrated. E.J.V.

Porcelain enamel steel tile. ANON. *Enamelist*, **12** [4], 5–7 (1935).—The development of the porcelain enameled tile industry is traced from its beginning in 1925 to the present. The transition from dark ground coats with about 71% opacity in white cover coats through white ground coats with higher opacity cover coats back to dark ground coats with highly opaque cover coats is described. Improvements in production methods are cited. Illustrated. E.J.V.

Porcelain enamel store front in new fields. BERNARD J. MCGARRY. *Enamelist*, **12** [5], 9–10 (1935).—Illustrated. E.J.V.

Porcelain enameling early history. ANON. *Better Enameling*, **6** [1], 19–21 (1935); see "An Ancient Art—," *Ceram. Abs.*, **13** [6], 164 (1934). E.J.V.

Porcelain enamels. A. I. ANDREWS. *Better Enameling*, **6** [1], 15–18 (1935).—A nontechnical explanation of the constitution and preparation of porcelain enamel, differentiating it from paints and lacquers, is given. The properties and proper care of enamel are summarized. Illustrated. E.J.V.

Preparing sheet iron for enameling. A. HESSE. *Emaillerie*, p. 5 (July, 1934); abstracted in *Verre & Silicates Ind.*, **5** [17], 330–31 (1934).—Pickling and cleaning of sheet iron is discussed in detail. The chief defects in enamels are as follows: (1) lack of adherence due to a greasy sheet iron; (2) "yellow" spots due to rust because of a too severe firing; (3) "pin" holes due to dust or faulty neutralization; (4) bubbles caused by a greasy surface, neutral salts (soda, borax), or metallic dust; (5) black spots due to impurities in the enamel; (6) "nail-scratches" produced by faulty firing; (7) a defective adherence and half-moon shaped cracks produced by insufficient firing; (8) "curling" of the enamel after coating due to bad neutralization. M.V.C.

Smelting furnace repair. GEORGE MACLAREN. *Enamelist*, **12** [4], 17 (1935).—A complete description of the steps in properly repairing frit smelting furnaces with the minimum loss of service time is presented. The repair of smelter stacks is mentioned. E.J.V.

Strength and Young's modulus of some ground-coat enamels for sheet iron. W. N. HARRISON, S. M. SHELTON, AND W. H. WADLEIGH. *Jour. Amer. Ceram. Soc.*, **18** [3], 100–106 (1935).

Systematic mill room operation. G. H. SPENCER-STRONG. *Amer. Enameler*, **7** [9], 3–4 (1934).—The importance of systematic mill room operation is discussed, and graphic methods of mill operation study and schedules are described in detail. K.H.T.

Testing molding and core sands. ANON. *Giesserei*, **21** [47–48], 497–504 (1934).—The new regulations and testing methods developed by German committees are reproduced in full and commented on. M.H.

White Castle prepares for building growth. ANON. *Enamelist*, **12** [5], 18–20 (1935).—Illustrated. E.J.V.

Zinc oxide. MILES M. ZOLLER. *Amer. Enameler*, **7** [9], 5 (1934).—Z. discusses various grades of zinc oxide. The source of material and the American and French methods of processing the raw ore for commercial use are given. K.H.T.

Zirconium oxide in glasses and enamels. II. C. A. DUTTON AND B. F. WAGNER. *Ceram. Ind.*, **24** [2], 88 (1935).—Tests made on the use of zirconium in enamels and glasses gave the following results: (1) The compressive and tensile strength of enamels containing zirconium was increased by 15 to 68% and the modulus of rigidity was lowered 26 to 37%. (2) White white or cream white color was obtained as desired. (3) Stability of color in color oxide mill additions was secured because of the original whiteness of zirconium and its inactivity with color oxides. (4) Irreducibility of zirconium oxide assisted in the control of high quality porcelain enamel. (5) Cost was stabilized. (6) Set of the enamel was improved. (7) It was suitable for use in acid-resisting enamels. (8) In proper combination zirconium oxide imparts a high degree of opacity to a silicate glass. (9) The amount of solution of zirconium oxide in glass is dependent on the kind and amount of other constituents, such as aluminum, zinc, calcium, and barium oxides, etc. (10) The zirconium oxide which goes into solution in the

glass imparts properties which should be of distinct advantage. For Part I see "Titanium—," *Ceram. Abs.*, **14** [3], 64 (1935). E.J.V.

PATENTS

Acid-resisting vitreous enamel. P. G. BARTLETT AND H. C. KREMERS (Röhm and Haas Co.). U. S. 1,990,812, Feb. 12, 1935. A step in dry-process enameling comprises coating heated articles with a frit composition containing in the melted batch zinc oxide 8 to 12%, alkalis 15 to 19.5% of which K_2O may vary 2 to 7%, lead oxide 5.5 to 12%, alumina 2 to 4.5%, silica 36.5 to 43%, titanium dioxide 5 to 10.5%, and zirconium oxide 9.5 to 12%.

Clay products for vitreous slips. C. J. KINZIE, C. H. COMMONS, JR., AND D. S. HAKE (Titanium Alloy Mfg. Co.). U. S. 1,988,800, Jan. 22, 1935. A method of making a clay product for use in vitreous enameling and glazing comprises mixing plastic clay and a water-insoluble metal hydroxide and then partly drying the resulting mixture.

Means for fastening metal shapes. D. E. Ross (Rostone, Inc.). U. S. 1,986,981, Jan. 8, 1935.

Method of annealing and cleaning ferrous articles. G. A. REINHARDT (Youngstown Sheet and Tube Co.). U. S. 1,989,884, Feb. 5, 1935. A method of annealing ferrous articles comprises immersing the articles in molten sodium carbonate, maintaining the articles submerged in the bath for a predetermined time less than one minute, and thereafter removing the articles and allowing them to cool.

Process for manufacture of enameled sheet iron articles. I. KREIDL. Brit. 421,171, Dec. 28, 1934.

Glass

Action of alcoholic solutions on glass surfaces. H. S. Y. GILL. Presented at meeting of Soc. Glass Tech., Oct., 1934, at Sheffield. Abstracted in *Pottery Gaz.*, **60** [691], 88 (1935). E.J.V.

Aggregation point and transformation point of glasses investigated by measurement of electrical resistance. W. HANLEIN AND M. THOMAS. *Glastech. Ber.*, **12** [4], 109–16 (1934).—An aggregation point is not detectable from measurements of the conductivities given. The transformation point likewise does not appear with static measurements. Appropriate viscosity measurements from below the transformation point to room temperature indicate that the transformation point is not recognizable by purely static methods. 11 references. G.R.S.

Anisotropy and structure of window glass. P. GAUBERT. *Compt. rend.*, **199** [24], 1402–1404 (1934).—It is shown that even thin glass plates can not be considered as isotrope as is usually assumed and their structure is mostly complex and greatly modified by temperature. Birefringence is very weak. M.H.

Arsenic in glass batches. ANON. *Glass Ind.*, **16** [2], 49–50 (1935).—Arsenic has been used in glass for (1) its effect as a refining agent, (2) its effect on the coloration of the glass, and (3) the production of opalescence. The opinions of various workers on how well arsenic answers these requirements are cited. E.J.V.

Artificial resins, etc., as the intermediate layer in safety glass. A. BRESSER. *Kunststoffe*, **24**, 30–32 (1934).—The use of various synthetic, artificial plastics in the manufacture of shatterproof glass is discussed. (*C.A.*)

Bullet-proof armor glass. FRITZ OHL. *Z. Ges. Schiess & Sprengstoffw.*, **29**, 109–11 (1934); abstracted in *Chem. Zentr.*, **ii**, 1511 (1934).—Data are given on the production, properties, performance, and uses of bullet-proof armor glass (multi-layer glasses with intermediate layers of celluloid, acetylcellulose, or ester of polyacrylic acid). When struck by a bullet, the surface of the glass has star-like fissures. There is no danger of piercing armored glass. See also "Safety Glass—," *Ceram. Abs.*, **14** [2], 36 (1935). M.V.C.

Color formation in glasses and glazes. F. H. NORTON. *Glass Ind.*, **16** [2], 45–48 (1935).—The subject of color formation is reviewed to bring together the modern ideas of the ceramist, the physicist, and the chemist. Colors in glasses and glazes are formed in four general ways: (1) solution of the transition elements in a clear base producing colored atoms or ions; (2) production of colored crystals in a base glass, usually from the transition elements; (3) production of a chromophore from elements of the second atomic group analogous to organic colors; and (4) a finely dispersed metal of colloidal size. Bibliography. E.J.V.

Corrosion of glass. W. E. S. TURNER. Presented at meeting of Soc. Glass Tech., Oct., 1934, Sheffield. Abstracted in *Pottery Gas.*, **60** [691], 88 (1935). E.J.V.

Displacement of transformation interval of glasses by pressure. E. JENCKEL. *Z. anorg. allgem. Chem.*, **216** [4], 349–52 (1934).—Calculations using the Clausius-Clapeyron equations were made to determine the effect of pressure on the transformation interval of glasses. Measurements were made on salicin, selenium, and boric oxide glasses; the values of dp/dt agree with the calculated values when $p = 1$ kg./cm.^{2} With increasing pressure to 1000 kg./cm.^{2}, dp/dt increases; accordingly it is evident that there is a considerable difference in c_1 and c_2 (the specific heats of the glass). L.T.B.

Durability of glass bottles. ANON. *Glass Rev.*, **10** [5], 71–73 (1934); for abstract see "Corrosion—," *Ceram. Abs.*, **14** [2], 33(1935). A.A.

Fourcault glass composition. J. M. MÜHLIG. *Glastech. Ber.*, **12** [2], 45–50 (1934).—M. discusses (1) properties and workability of mouth-blown sheet glass, (2) development of glass compositions suitable for a Fourcault machine, (3) importance of viscosity and devitrification temperature in the drawing process, (4) the question of resistance and stratification, (5) introduction of metallic oxides for better flowing and drawing of the glass, and (6) improvement of glass surface and decreasing production costs. G.R.S.

Fuel changes in glassmelting furnaces. H. MAURACH. *Glastech. Ber.*, **11** [12], 437–44 (1933).—A discussion is given of (1) basis for the change of fuels, (2) properties of hot gases, analyses, heating values, combustion temperatures, length of flame and speed of combustion, the gas-air relationship, kiln atmosphere, tar and oil content of gases, luminosity of flames, sulfur content of gases, (3) burners, and (4) regenerators. 27 references. G.R.S.

Fuel oil *vs.* producer gas in glassmelting. II. JOHN

KLUMPP, JR. Presented at 2d Conference on Glass Problems, Nov., 1934, Univ. of Ill., Urbana. *Ceram. Ind.*, **24** [2], 120–22 (1935).—A study of actual plant conditions applied to cost and suggestions for buying the right kind of fuel oil for glassmelting are presented. For Part I see *Ceram. Abs.*, **14** [3], 65 (1935). E.J.V.

Glass-bottle machinery. I. W. A. MOORSHEAD. *Mech. World*, **97** [2508], 77–79 (1935).—The mechanization of glass-bottle manufacture commences with the mechanical handling of raw materials and the automatic separation of impurities. Weighing and furnace control may be partly manual control, but the actual glassblowing machines are fully automatic. The final stage is the annealing of the bottles in suitable plants. Illustrated. E.J.V.

Heat-technical meeting of German glass industry. ANON. *Keram. Rund.*, **42** [24], 293–95 (1934).—Abstracts of papers read at the meeting held in Wiesbaden, 1934, are given. The following reports are of interest: (1) "Glassmelting furnaces of old times," by H. Maurach (*Ceram. Abs.*, **14** [3], 65 (1935)); (2) "Electric glass furnaces," by E. Knoops; (3) "Progress in the construction of glass furnaces," by K. Metzger; (4) "Improvements in important elements of furnace building," by W. Giegerich; (5) "Tank blocks of high quality," by H. Knuth. M.V.C.

Identification of glass splinters. N. A. MARRIS. *Analyst*, **59**, 686–87 (1934).—A case of theft in New Zealand required identification of splinters of glass. Tests applied to 65 varieties of glass were as follows: (1) refractive index, by the shadow or Van-der-Kolk method; (2) specific gravity, by flotation in liquids of known density (bromoform, etc.); (3) fluorescence in ultra-violet light. The only two samples which agreed in all tests were the original and the splinters from the suspect's attaché case. H.H.S.

Implications of the known variation in strength of glass. W. M. HAMPTON AND C. E. GOULD. *Jour. Soc. Glass Tech.*, **18** [71], 194–200 (1934).—Physical properties of glass may be divided into (1) those which do not vary between one specimen and another made from the same batch by more than the error of determination, and (2) those properties which vary over a range of values however accurately the determinations are made, examples of which are impact strength, tensile strength, and thermal endurance. Impact strength is a function of tensile strength and the thermal endurance is proportional to the ratio

$$\frac{\text{Tensile strength}}{\text{Coefficient of expansion} \times \text{modulus of elasticity}}.$$

The coefficient of expansion and the modulus of elasticity come under the first group, so that the variations which occur in the three physical properties of the second group reduce to a variation in tensile strength. The coefficient of variation of thermal endurance is always about 10%, while the standard deviation from the published results of tensile strength determinations is found to be of the same order. Assuming that any property of glass which involved tensile strength would show variations in accordance with the "normal" law and coefficient of variation of the order of 10%, the probability of the occurrence of variations of different extents in the property considered could be computed. Applications of this to the thermal endurance tests are given. Difficulties arising in predicting fracture are considered. In the case of articles made of glass, it becomes necessary to use a high factor of safety because of the relatively large standard deviation. A.A.

Jena glass history. ANON. *Deut. opt. Wochenschrift*, **55** [38], 615–16 (1934); abstracted in *Physik. Ber.*, **15** [24], 2160 (1934). M.H.

Light in glass packages. ANON. *Sci. Amer.*, **152** [1], 27 (1935).—This is a brief description of manufacturing light bulbs. Illustrated. W.M.C.

Microchemical analyses of glasses. V–VI. Detection of minute quantities of cobalt and nickel in glass. W. GEILMANN AND O. MEYER-HOISSEN. *Glastech. Ber.*, **12** [9], 302–307 (1934).—A method is described for detecting minute quantities of cobalt in glasses, depending on the concentration of the cobalt by electrolysis of an ammoniacal solution and microchemical confirmation. A similar method is useful for the detection of nickel. By using 1 g. glass, nickel in amounts of 5×10^{-6}% is recognized, and the corresponding amount of nickel is quantitatively estimated. For Part IV see *Ceram. Abs.*, **12** [2], 49 (1933). G.R.S.

Potassium carbonate in glassmaking. S. R. SCHOLES. *Ceram. Ind.*, **24** [2], 83–85 (1935).—Glassmakers' potash is the sesquihydrate K_2CO_3–$1^1/_2H_2O$. The manufacture and properties of the material are discussed. Due to the high viscosity of potash glasses it is customary to use some soda with the potash to reduce the viscosity and for a better fluxing effect. The addition of lead oxide also reduces the viscosity of potash glasses and makes a glass which lends itself to hand-working because of its long working range. Potash glasses do not lose their luster on weathering because the deliquescent nature of the carbonate forms a moist film on the surface instead of a dry film. Potash glass has a better bell-like tone when tapped lightly. In etching with hydrofluoric acid the potash glasses present rougher and therefore less transparent surfaces. Interesting differences between potash and soda appear when colorants are introduced. The best crystal glass contains potash as the principal alkali. Illustrated. E.J.V.

Safety glass status and development. FRITZ OHL. *Glastech. Ber.*, **12** [2], 50–53 (1934).—The following points are covered: (1) general consideration of the safety glass industry, (2) purposes and properties of safety glass, (3) filler materials and their compositions, (4) softening materials and adhesives, (5) ways and means of improvement, (6) production problems, (7) strained glass as safety glass, and (8) organic safety glasses. G.R.S.

Seed in glass. GOODING. Presented at meeting of Midlands Section, Soc. Glass Tech., Dec., 1934. Abstracted in *Pottery Gaz.*, **60** [691], 91 (1935). E.J.V.

Selenium in glasses. W. HOFLER. *Glastech. Ber.*, **12** [4], 117–34 (1934).—The experiments were carried out in a furnace in which the atmosphere could be controlled. With a neutral atmosphere a rose-red color is obtained. With oxygen or air the top layer of the melt is decolorized. With 3% CO in a neutral gas a brown color is produced while with stronger reduction the melt is decolorized. In oxygen with selenium introduced as selenate the color-

less top layer is deeper than with selenium, and with selenides there is no colorless layer but a strong rose color. In neutral gases there is no colorless layer and selenates or selenites color more weakly than elemental selenium, while selenides produce brown. With reduction in hydrogen and carbon monoxide the selenates show colorless, brown, and rose layers. Selenides under the same conditions show brown and colorless layers. Increasing the Se content decreases the effect of the atmosphere. The value of sodium selenite lies in its lessened tendency to produce brown and not in its higher coloring power. The effect of the melting temperature in the usual range is insignificant. By flowing the glass the effect of the contacting atmosphere is greatly increased. Introduction of reducing or oxidizing compounds into the glass gives rise to the same series of color stages. Contrary to some reports the speed of cooling has no effect on the color. Composition has some effect, since a high alkali glass gives a strong yellow color. No distinction exists between potash and soda glasses. Color changes are to be explained as different stages of oxidation and not degree of dispersion. There are two colorless stages representing complete oxidation or reduction and the intermediate brown and red stages. G.R.S.

Surfaces on glass determined by radio chemical methods. M. HECKTER. *Glastech. Ber.*, **12** [5], 156–71 (1934).—A radioactive procedure is described for determining the extent of surface of fine particles. By comparing the emanation activities of a series of powdered glass fractions (2 Ra-glasses and 2 ThX-glasses) it was found that completely uniform sieving of similar materials gives no definite surface within a fraction. A regular dependence of formation of surface on the amounts and degrees of fineness of the powder and the choice of sieve limits can not be established. By comparing the emanation activities of powders with those of measurable surfaces the surface extent of powders could be determined satisfactorily. The results furnish for the first time a measure of the recoil distance of Ra and Th emanations in a glass of the composition $Na_2O{\cdot}CaO{\cdot}6SiO_2$ of 339.10^{-8} cm. and 435.10^{-8} cm., respectively. An equation has been developed which permits calculation of the surfaces of amorphous and isotropic compounds from their emanation behavior. 17 references. G.R.S.

Temperature influence on bursting pressure of bottles. B. LONGMUIR AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **18** [71], 252–59 (1934).—Determinations of the bursting pressure of bottles of the composition SiO_2 70.3, Al_2O_3 2.5, CaO 9.2, Fe_2O_3 0.2, MgO 1.7, Na_2O 16.1 were made under carefully controlled conditions using both water and oil as pressure media at various temperatures. The bottles were of a type used for containing pasteurized beer and were of the size described as an imperial quart. The mean thickness measured for 468 bottles at a height of 10 to 12 cm. from the bottom was 5.4 mm., only 10% falling outside the range 4.0 to 6.0 mm. The bursting pressure was found to diminish progressively with rise of temperature in such a way that the product of absolute temperature and bursting pressure was approximately constant over the temperature range investigated. Slight variations in the wall thickness and in the state of annealing, as revealed when the specimens were examined in a polarized light, did not show any direct connection with the bursting pressure of the bottles, which could be regarded as satisfactorily commercially annealed. The mean value of the linear thermal expansion of the glass was found to be 960×10^{-8} for the temperature range 0 to 150°C. The maximum increase in the internal area resulting from this expansion is calculated to be of the order of 0.25%, a value far too small to explain the substantial diminution in the bursting pressure with the increase in temperature.

COMPARISON OF BURSTING PRESSURES (LB./IN.^{2}), USING WATER AND OIL AT DIFFERENT TEMPERATURES

Temperature (°C)	Bursting pressures (lb./in.^{2}) Water		Oil		(Absolute) temp. × Pressure bursting	
	Number tested	General mean	Number tested	General mean	Water	Oil
15	74	388			112×10^3	
25	79	343	60	343	102×10^3	102×10^3
40	79	317	20	315	99×10^3	98.6×10^3
50	77	313			101×10^3	
60	82	310	40	315	103×10^3	105×10^3
75	83	301	23	304	105×10^3	106×10^3
95	73	292	57	304	107×10^3	112×10^3
150			64	266		112×10^3

A.A.

Temperature influence on duration of fusion of a pot of crystal glass. A. THOUVENIN. *Céram., Verrerie, Email.*, **2** [6], 249–52 (1934).—The working time for a pot of crystal glass is cut down appreciably by maintaining a higher temperature and so permitting the more rapid removal of bubbles. Curves showing the relation of temperature to bubble size are given. M.H.B.

Temperature interval of the transformation of glasses determined by change of viscosity with temperature. ERNST JENCKEL. *Z. anorg. allgem. Chem.*, **216** [4], 367–75 (1934).—For the determination of t_w (the temperature at which a glass changes from the brittle to the highly viscous state), viscosity measurements were made. Three silicate and boric oxide glasses were employed. For these glasses the viscosity at t_w always has the value 1.86×10^{13} absolute units. T_w can therefore be determined by measuring (1) isothermal rate of flow by relative lengthening of a loaded glass thread, and (2) total increase in length of a glass thread on slow heating. L.T.B.

X-ray diffraction of vitreous silica. B. E. WARREN. *Z. Krist.*, **86** [5–6], 349–58 (1933).—X-ray diffraction patterns of vitreous silica and Pyrex brand glass each show a strong but broad diffraction ring at a scattering angle corresponding to a value, d, in the Bragg law of 4.32 Å for silica and 4.26 Å for Pyrex. Two methods of interpretation are suggested: the diffuse ring is due to (1) extremely small crystals of cristobalite, or (2) scattering from a noncrystalline random network. On the first hypothesis the observed ring is the strong (111) reflection from cristobalite crystals about 15 Å in size. A number of objections seem to rule out the crystallite hypothesis. On the random network hypothesis, it is postulated that the atoms are bound together in the same way as in the crystalline forms of SiO_2 but form a continuous noncrystalline network. Each Si is tetrahedrally surrounded by 4 O and each O is shared between two tetrahedral groups. Each tetrahedral group has 4 nearest neighbors at 3.1 Å and 12 next nearest at 5.0 Å. Beyond this the distances are indefinite. An expression for the intensity of scattering from such an array leads to an intensity curve in satisfactory agreement with the experimental curve. The random network picture

of the vitreous state, deduced from X-ray diffraction study, is in complete agreement with the conclusions reached by Zachariasen from consideration of the chemical and physical properties of glass. G.R.S.

BOOK

Standards in the Glass and Porcelain-Faience Industries. ALL-UNION COMMITTEE OF STANDARDIZATION AND RATIONALIZATION. State Pub. House of Standardization and Rationalization, Moscow, 1934. 210 pp. Price 8 R. All standards approved by this Committee (V.K.S.) are outlined in detail. They include sheet glass, bottles, apothecary and medicinal utensils, optical glasses, technical glass, glass articles used in daily life, laboratory and table porcelain utensils, electrical porcelain, and faience. The book contains official state standards. S.I.PERKAL

PATENTS

Abrading machine. A. E. MAYNARD (American Optical Co.). U. S. 1,989,939, Feb. 5, 1935.

Adaptors of glass for scientific apparatus. TRIPLEX SAFETY GLASS CO., LTD., AND L. V. D. SCORAH. Brit. 421,619, Jan. 9, 1935.

Annealing leer. E. L. WALTERS (Libbey-Owens-Ford Glass Co.). U. S. 1,989,957, Feb. 5, 1935.

Apparatus for:

Circulating molten glass. R. W. CANFIELD (Hartford-Empire Co.). U. S. 1,988,783, Jan. 22, 1935.

Cutting glass. C. E. HAHN (General Electric Co.). U. S. 1,990,375, Feb. 5, 1935.

Making laminated glass. F. R. MURPHY (J. P. Devine Mfg. Co., Inc.). U. S. 1,987,306, Jan. 8, 1935.

Making sheet glass. K. G. KUTCHKA (Pittsburgh Plate Glass Co.). U. S. 1,988,560, Jan. 22, 1935. WALTER RUCH (Pittsburgh Plate Glass Co.). U. S. 1,988,572, Jan. 22, 1935.

Manufacture of laminated glass or similar processes. G. D. PETERS & Co., LTD., AND R. I. D. ARTHURTON. Brit. 422,709, Jan. 30, 1935.

Severing sheet glass. FRED TASHER (Pittsburgh Plate Glass Co.). U. S. 1,988,580, Jan. 22, 1935.

Edge grinding machine. J. P. CROWLEY (Libbey-Owens-Ford Glass Co.). U. S. 1,987,054, Jan. 8, 1935.

Gas-filled electrical discharge lamps and tubes. V. C. FROM. Brit. 421,537, Jan. 9, 1935.

Glass-cutting apparatus. A. C. OAKES. U. S. 1,988,393, Jan. 15, 1935. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,988,565, Jan. 22, 1935.

Glass gathering and forming machine. FRANK O'NEILL (Owens-Illinois Glass Co.). U. S. 1,988,699, Jan. 22, 1935.

Glass grinding apparatus. C. B. SCHAFER (Libbey-Owens-Ford Glass Co.). U. S. 1,990,002, Feb. 5, 1935.

Glassmelting tank. W. A. MORTON (Amco, Inc.). U. S. 1,991,331, Feb. 12, 1935.

Glass severing mechanism. THOMAS STENHOUSE AND DAVID STENHOUSE. (Hazel-Atlas Glass Co.). U. S. 1,987,249, Jan. 8, 1935.

Glassware forming machine. C. B. SMITH (Owens-Illinois Glass Co.). U. S. 1,988,579, Jan. 22, 1935.

Glassworking apparatus. W. C. WEBER (Corning Glass Works). U. S. 1,988,883, Jan. 22, 1935.

Grinding or polishing machine. C. E. EVANS. U. S. 1,988,649, Jan. 22, 1935. In a grinding or polishing machine a hinged support, a lens block associated with the support and arranged to accommodate itself to a substantial range of universal movement for permitting the lens to accommodate itself in proper relation to the grinding or polishing member, and means for limiting the movement of the lens block in certain directions are described.

Laminated glass. RÖHM AND HAAS CO. Brit. 421,541, Jan. 9, 1935. G. B. WATKINS (Libbey-Owens-Ford Glass Co.). U. S. 1,989,959, Feb. 5, 1935.

Leer construction. J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,988,110, Jan. 15, 1935.

Machine for:

Cutting, shaping, and bevelling watch crystals, etc. JEROME SHIFFMAN. U. S. 1,991,231, Feb. 12, 1935.

Forming glass bottles, etc. A. N. CRAMER (Owens-Illinois Glass Co.). U. S. 1,986,918, Jan. 8, 1935.

Forming glass lens blanks. A. N. CRAMER (Owens-Illinois Glass Co.). U. S. 1,986,917, Jan. 8, 1935.

Making blown hollow glassware. A. N. CRAMER (Owens-Illinois Glass Co.). U. S. 1,986,919, Jan. 8, 1935.

Molding glass articles. R. G. ALLEN (Owens-Illinois Glass Co.). U. S. 1,986,912, Jan. 8, 1935.

Producing hollow glassware. A. LAWSON AND RANKIN AUTOMATIC GLASS FEEDER CO., LTD. Brit. 421,562, Jan. 9, 1935. C. H. RANKIN AND RANKIN AUTOMATIC GLASS FEEDER CO., LTD. Brit. 421,563, Jan. 9, 1935.

Method and apparatus for:

Blowing bulbs, etc. C. A. BROWN, C. W. CRAIG, AND F. B. VAN SICKLE (General Electric Co.). U. S. 1,988,297, Jan. 15, 1935.

Gathering glass. H. R. SCHUTZ (Libbey Glass Mfg. Co.). U. S. 1,987,129, Jan. 8, 1935.

Handling glass sheets. EUGENE GENTIL (American Bicheroux Co.). U. S. 1,988,892, Jan. 22, 1935.

Making hollow glass articles. A. E. SCHEUERMAN (Owens-Illinois Glass Co.). U. S. 1,988,574, Jan. 22, 1935.

Manufacture of blown glassware. A. J. SMITH (Hartford-Empire Co.). U. S. 19,439, Jan. 22, 1935 (reissue of original, U. S. 1,896,870, Feb. 7, 1933).

Manufacturing stoppers of ground glass. TRIPLEX SAFETY GLASS CO., LTD., AND L. V. D. SCORAH. Brit. 422,848, Jan. 30, 1935.

Working glass. P. H. D. DE FONBRUNE. U. S. 1,987,734, Jan. 15, 1935.

Method of manufacturing glass tubing. I. O. PEDERSEN. U. S. 1,987,633, Jan. 15, 1935.

Method and means for producing double-walled glass vessels. J. DICHTER. Brit. 422,436, Jan. 23, 1935.

Method of melting glass. W. W. OAKLEY (Corning Glass Works). U. S. 1,988,915, Jan. 22, 1935. The method of melting glass includes mixing alumina with cullet, introducing onto the bottom of the melting con-

tainer a layer of the mixture, fusing the mixture to produce a highly viscous layer, and making the glass melt on top of the fused layer.

Method of producing luminescent glass. M. FISCHER, H. FISCHER, AND M. FISCHER. Brit. 421,142, Dec. 28, 1934.

Production of ground-glass joints. TRIPLEX SAFETY GLASS CO., LTD., AND L. V. D. SCORAH. Brit. 422,847, Jan. 30, 1935.

Production of conical glass joints. TRIPLEX SAFETY GLASS CO., LTD., AND L. V. D. SCORAH. Brit. 422,846, Jan. 30, 1935.

Smoothing glass sheets. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Brit. 421,922, Jan. 16, 1935.

Supporting means for furnace structures. G. E. HOWARD (Hartford-Empire Co.). U. S. 1,989,985, Feb. 5, 1935.

Structural Clay Products

Brick-surfaced roads. ANON. *Clay Prod. Jour. Australia*, **2** [2], 30 (1934).—Brick laid flat giving a thickness of 3 in. compare favorably in cost and efficiency with other types of road surface. An English commission (East Lancashire) has reported that brick is superior in impermeability, durability, foothold, nonskid quality, noiselessness, drainage, rate of drying, freedom from mud and dust, and replaceability. At dangerous corners and on curves brick is especially recommended. H.H.S.

Correlation of laboratory tests with weathering properties of brick. B. BUTTERWORTH. *Brit. Clayworker*, **43** [513], 285–95 (1935). R.A.H.

De-airing dry press bodies. W. C. RUECKEL AND R. B. KEPLINGER. *Brick Clay Rec.*, **86** [1], 30–32 (1935).—A report of tests made on products de-aired by evacuation of the mold box, saturating loose clay with gas, and by double pressing of the product is presented. A comparison of brick formed at high pressures and those formed under normal plant practice in commercial tests indicates that the former are much stronger, denser, and more resistant to load deformation and should be suited for refractory service where high strength and resistance to slag penetration is desired. Illustrated. E.J.V.

De-airing improvements in pipe. J. B. RANKIN. *Brick Clay Rec.*, **86** [1], 28 (1935).—After eight months' use of de-airing, R. lists 16 advantages and 3 disadvantages in producing sewer pipe by this method. E.J.V.

Drying de-aired sewer pipe. J. OTIS EVERHART. *Brick Clay Rec.*, **86** [1], 26–28 (1935).—In the majority of installations drying behavior has been improved by de-airing. Weakness zones at the issue holes cause difficulty in drying but by altering the forming operation to reduce the concentration of weakness at the issue holes or by changing drying conditions, drying trouble may be averted. The drying practice of almost any plant may be improved by more careful manipulation of the available floor space with the object of drying under conditions of partial humidity control. E.J.V.

Jointing of stoneware sewerage pipes. ANON. *Clay Prod. Jour. Australia*, **1** [2], 7–9 (1933).—There has been much activity in Australia, *i.e.*, holding of Government Commissions and investigations of Public Health Engineers, on the relative cost, efficiency, and durability of stoneware *vs.* concrete, length of pipe, etc., in sewerage systems. The best joint for stoneware is a combination of bitumen and rubber. See also *Ceram. Abs.*, **14** [3], 70 (1935). H.H.S.

Permeability tests of 8-in. brick wallettes. L. A. PALMER AND D. A. PARSONS. *Proc. A.S.T.M.*, **34** [Part II], 419–53 (1934).—A total of 240 wallettes made with 10 representative mortars and 5 makes of brick were aged for 3 months and tested for permeability by keeping a constant level of water in a shallow reservoir on the upper surface of each test specimen. The following conclusions are believed to be warranted: (1) The relative water-tightness of the wallettes depended on the properties of the brick and mortars, the most important being the water-retaining capacities of the mortars and the absorption rates of the brick. (2) In the tests as conducted the water-tightness of the test wallettes was controlled more by the brick than by the mortar properties. There is a reasonable doubt as to this being the case in walls of buildings wherein the joints are often only partially filled. (3) With all joints well filled the most water-tight wallettes, considering all mortars, were obtained with smooth, impervious brick set dry and with smooth, porous brick set wet. (4) From the standpoint of water-tightness, cracks in brick are very undesirable and accelerate the rate of water transmission through the wall. (5) The wallettes made with porous brick set dry were more water-tight with the mortars of high than with mortars of low water-retaining capacity. (6) With rough-surfaced brick set wet, the wallettes made with the relatively workable mortars were more water-tight than those made with the other mortars. (7) Seventy-three per cent of the total number of leaks in the 240 wallettes appeared at the junctures of the vertical and horizontal mortar joints. (8) The rate of water transmission through the wallettes made of porous brick increased as the brick became saturated during the tests. (9) The rate of water transmission through the test wallettes was independent of the permeabilities of the mortars used. R.A.H.

Producing de-aired sewer pipe. J. OTIS EVERHART. Presented at meeting of Ohio Ceramic Industries Assn., Nov., 1934, Columbus, Ohio. *Brick Clay Rec.*, **86** [1], 24–26 (1935).—A review of a special investigation of de-aired sewer-pipe problems is presented. New ideas in manufacture are considered. It is shown that de-airing improves the general qualities of sewer pipe. Illustrated. E.J.V.

Reinforced brick masonry bridge. J. R. BURKEY. *Brick Clay Rec.*, **86** [1], 8–9 (1935).—Built as a PWA project, the bridge at Sugar Creek, Ohio, was constructed at a cost almost identical with that of reinforced concrete structures of similar design. Construction details are given. Illustrated. E.J.V.

Sewage pipes. Relation of trench width to load on pipes. G. C. D. LENTH. *Clay Prod. Jour. Australia*, **1** [2], 17–22 (1933).—A table is given of the maximum widths of trench permissible for safety in relation to the internal drain, thickness, and length of the pipe, as based on experimental data of the Iowa Engineering Experiment Station. H.H.S.

Stoneware *vs.* concrete for sewage pipes. F. A. EASTAUGH. *Clay Prod. Jour. Australia*, **1** [4], 13–15 (1934).—To a Government Commission on this subject, E., professor of Engineering Technology at Sydney Univ., described his experiments showing that concrete pipe of whatever quality are attacked by H_2S and that stoneware is not. H.H.S.

Stoneware pipe: Crushing strength tests. A. W. JONES. *Clay Prod. Jour. Australia*, **1** [4], 15 (1934).—The 3-edge bearing and the sand-bedding tests were compared on pipe from 4 in. to 24 in. in length. The sand test gave a strength 34% higher than the 3-edge. Both tests were well above government specifications. H.H.S.

Stoneware sewer pipe: porosity in relation to strength. SYDNEY WATER BOARD. *Clay Prod. Jour. Australia*, **1** [2], 9–11 (1933).—Pipe 9 in. in diameter and 2 ft. long were classified into 12 groups according to their porosity and tested for crushing load. The strongest pipes were those of $3^1/_2$ to $6^1/_2$% porosity. Porosities above or below these limits were definitely in the below-average crushing load. The loads were 7776 lb. maximum (4 to $4^1/_2$% porosity) and 6092 lb. minimum (below 3%). H.H.S.

Testing stoneware pipe. J. MACD. ROYLE. *Clay Prod. Jour. Australia*, **1** [3], 11–15 (1933).—The three main tests are crushing strength, porosity, and hydrostatic permeability. Crushing strength is tested either by the sand bearing or the 3-edge bearing methods. Porosity is tested by boiling for 1 hr. (British), 5 hr. (U.S.A.), or cold water for 24 hr. (Australia); 4% porosity Australia equals 6.78% British and 7.57% U.S.A. The British method is preferred. The permeability test is regarded as the most important. A pressure of 13 lb./sq. in. is maintained for 0.05 minute. There must be no moisture on the external surface. H.H.S.

Wall brick researches in England. I. *Rept. Bldg. Research Board*, pp. 44–51 (1933); abstracted in *Tonind.-Ztg.*, **58** [80], 983 (1934).—The report deals with (1) the firing of brick, (2) physical properties, (3) effect of water in brick, (4) salt efflorescences, and (5) methods for determining the physical state of brick. **II.** *Rept. Bldg. Research Board*, pp. 51–55 (1933); *Tonind.-Ztg.*, **58** [89], 1089 (1934).—Crystallization tests, natural effect of frost and laboratory experiments, and stability of brick buried in the ground are discussed. M.V.K.

PATENTS

Brick building construction. L. F. STARKS AND E. F. FLANDERS. U. S. 1,990,008, Feb. 5, 1935.

Manufacture of rustic brick. C. H. ATKINSON AND C. A. BOULTON. Brit. 421,988, Jan. 16, 1935.

Refractories

Action of sodium sulfate on refractory materials. O. BARTSCH. *Glastech. Ber.*, **11** [8], 285–93 (1933).—Refractories were tested for their resistance to attack by melts of soda, sodium sulfate, and mixtures of sulfate and carbon. In the case of soda there was marked decrease of resistance with increasing clay content, while for sulfate the opposite was true. The mixture of sulfate and carbon showed a similar corrosive action to that produced by the soda melt. The very corrosive action of sulfate melts in which the gall has been removed by reduction is due to the localized surface area with a high concentration of alkali. Certain clays cause a peculiar deformation of the refractory in fused sodium sulfate which is minimized by proper prefiring. This is suggested as a test to aid in the determination of the proper firing conditions for refractories. G.R.S.

Apparatus of the inorganic-chemical industry. B. WAESER. *Werkstoffe & Korrosion*, **9** [12], 45–47 (1934). In the field of refractories, a new line besides the Al_2O_3-containing materials (up to 90%) is the "Carsial" brick containing SiC with the following groups:

	SiC (%)	Density	Compression strength (kg./cm.²)	Softening point under 2 kg./cm.² (°C)
Carsial I	90	2.40	>1000	>1750
Carsial II	80	2.35	>1000	>1750
Carsial III	70	2.30	>1000	1660
Carsial IV	60	2.25	1000	1550
Carsial V	50	2.20	800	1450

Some technical porcelains are described which stand temperatures up to 2000°C. Heat-insulating materials are made of the oxides of Al, Mg, Be, Zr, and Th and can be used for temperatures from 1900 to 2500°C. M.H.

Cast saggers bring savings to firing operations. GORDON KLEIN. *Ceram. Ind.*, **24** [2], 86–87 (1935).—Cast saggers are much thinner walled than machine- or hand-made saggers because (1) by this method of forming the sagger is rigid enough to permit handling and finishing when taken from the mold, and (2) the fired body has a strength two to three times that of pressed sagger bodies. This high strength is due both to body composition and method of forming. Because of the thinner walls the capacity of the saggers is greater. Tests indicate that an average life of over 100 trips in glost firing will be experienced. In cast saggers a loss due to sagger dirt of less than 1% has been shown in contrast to the usual 8 to 12% loss in pressed saggers. Illustrated. E.J.V.

Chemically resistant refractory materials for sodium sulfide furnaces. P. P. BUDNIKOFF AND S. A. GICHAREVITSCH. *Trans. Ceram. Soc.* [Eng.], **33** [9], 368–78 (1934).—The comparative ability of eleven refractory materials to withstand the chemical action of the alkalis and gases of the sodium sulfide furnace at temperatures of 1000 to 1100°C was investigated. It was found that carbonaceous, silica, magnesite, and chromite-magnesite brick were highly resistant, and that the resistibility of grog brick increases with Al_2O_3 content. Illustrated. R.H.H.P., JR.

Experiments on frothed clays. S. R. HIND. Appendix by A. J. DALE. *Trans. Ceram. Soc.* [Eng.], **33** [12], 544–48 (1934); reprinted from *Bull. Brit. Refrac. Research Assn.*, No. 20 (May, 1929); for abstract see *Ceram. Abs.*, **13** [10], 272 (1934). R.H.H.P., JR.

Flat suspended furnace arches and walls. ANON. *World Power*, **23** [133], 36 (1935); see also *Ceram. Abs.*, **14** [2], 47 (1935). E.J.V.

Furnace design in steel and malleable foundries. P. RHEINLÄNDER. *Giesserei*, **21** [45–46], 476–80; [47–48], 504–507 (1934).—Modern development caused by the trend to use high-grade remote gas supplies and electric current as heating fuels is reviewed, and design details and operating data of melting, core-drying, annealing, and malleableizing furnaces are given and compared for different fuels. M.H.

High-temperature insulation for industrial furnaces. II. N. ALLEN HUMPHREY. *Blast Fur. Steel Plant*, **23** [1], 85–87 (1935).—Movement of air over the outer surface reduces the surface resistance. In the case of heavily insulated furnace walls, the surface resistance is so small a part of the total that it has little effect on the heat loss. Under such conditions the outer surface temperature is lowered by the air moving over it but the heat loss is only slightly increased. An example of the calculations involved in figuring heat losses for various types of furnaces is given. For Part I see *Ceram. Abs.*, **14** [3], 72 (1935). E.J.V.

Hydraulic refractory cements. J. A. *Rev. mat. constr. trav. pub.*, No. 299, pp. 243–44 (1934).—Refractory Kestner cements are real aluminous cements in which water plays the important rôle in setting, crystallization, and dissolution of the anhydrous monocalcium aluminate into hydrated aluminate. This water takes part in the setting and hardening which depends on the cohesion and the adherence of the crystals formed. Kestner cements lose their cohesion only partially on heating. They become friable only at a temperature higher than that required to expel the water of crystallization which entirely disappears on heating over 1100°. This relative friability or deficiency in cohesion is due to the special properties of the hydrated calcium aluminate relating this salt to silico-aluminates known as "zeolites." M.V.C.

Industrial Refractories Corp. formed. ANON. *Glass Ind.*, **16** [2], 52 (1935).—This corporation of Pittsburgh, Pa., has been formed to handle the new process of glass tank construction, hinging on the use of "Refractite," a recently developed impregnating material that possesses high refractory powers and results in a curing process of only 24 hr. instead of a week, lower heat loss, lower tendency to spall off, etc. E.J.V.

Permeability of refractory materials. ERIC PRESTON. Presented at meeting of Soc. Glass Tech., Dec., 1934, London. Abstracted in *Pottery Gas.*, **60** [691], 89–91 (1935). E.J.V.

Precision measurements of lattice constants of silicon carbide. G. BORRMANN AND H. SEYFARTH. *Z. Krist.*, **86** [5–6], 472–73 (1933).—X-ray data obtained from the second modification of SiC gave the following results: $a = 3.076$ and $c = 15.07$. The calculated density was 3.212. G.R.S.

Reaction-expansion measurements on chromite and allied spinels. J. H. CHESTERS AND C. W. PARMELEE. *Jour. Amer. Ceram. Soc.*, **18** [3], 94–100 (1935).

Refractories materials symbols, abbreviations, and definitions. FRANCIS J. WILLIAMS AND ELLIOTT P. BARRETT. *Bull. Amer. Ceram. Soc.*, **14** [2], 82–87 (1935).

Refractories in 1934. G. G. COOLIDGE, L. C. HEWITT, AND R. P. HEUER. *Blast Fur. Steel Plant*, **23** [1], 41–43 (1935).—Comments on new developments in refractories made during 1934 are presented by manufacturers. E.J.V.

Researches in high temperatures. W. DAWIHL. *Tonind.-Ztg.*, **58** [37], 449–51; [38], 463–65; [39], 477–78; [40], 485–87 (1934).—The sintering behavior and the production of usable ware from alumina were studied, and the technical manufacture of as pure zircon metal as possible was undertaken. A short review of methods known is given. A carbon-grit furnace with ZrO_2 inner tubes of 15 cm. width in the interior and a gas furnace with the surface combustion system of Salmang and Brors (*Ceram. Abs.*, **10** [1], 42 (1931)) was used for firing the samples. Crystalline $Al(OH)_3$ was used as a raw material. The oxide produced contained less than 0.01 Fe_2O_3 and less than 0.1% SiO_2 when heating to 1000°; 92.2% of it passed through the 0.06-mm. screen. The residue amounted to 4.2% and that remaining from sifting through the 0.09-mm. sieve was 3.4%; 0.2% remained after sifting through the 0.2-mm. sieve. The vitrification of the pure materials occurs suddenly at about 1850°. Small additions of MgO (about 1%) and Fe_2O_3 promote sintering without greatly lowering the melting point. The following composition for cast bodies was found to be the best: 500 g. Al_2O_3 (wet fine grinding), 350 cc. water, 50 g. $MgCl_2 \cdot 6H_2O$ in a solution of 80 cc., and 2 cc. of a 50% zircon oxychloride solution. The shrinkage of the products of the oxide ground wet was higher than the shrinkage of that ground dry (28%). An addition of prefired oxide lowered shrinkage but promoted porosity. An arc furnace was used for the production of the Zr-metal. The ZrO_2 was free from Fe and Ti. Beech-wood coal, poor in ash, was used for reducing. The composition of the product obtained was 71% zircon carbide, 20% zircon metal, and 9% zircon oxide. Refining in a CaO crucible yielded a composition of 48% zircon carbide, 46% zircon metal, and 6% zircon oxide. A Zr-Fe alloy was also produced. M.V.C.

Silica brick from insulated and uninsulated basic open-hearth roofs compared. FRED A. HARVEY. *Jour. Amer. Ceram. Soc.*, **18** [3], 86–94 (1935).—Illustrated with photomicrographs and color plate.

Testing refractory materials. CYRIL EDWARDS. *Trans. Ceram. Soc.* [Eng.], **33** [7], 260–73 (1934).—E. presents a critical study based upon laboratory experience of a number of standard tests of refractory materials such as after-contraction of fire brick and silica brick, refractoriness, including both the bending and the squatting tests, refractoriness under load, spalling of silica brick, and tolerances in shape and dimensions of brick. R.H.H.P., JR.

BOOKS

Calcining Grog. G. O. GROSS. State Sci. Tech. Pub. House of Bldg. Industry and Shipbuilding, Moscow-

Leningrad, 1934. 100 pp. Price 1 R. This very useful and authoritative brochure deals with grog and its calcining in periodic, Hofmann, shaft, rotary, and tunnel furnaces. S.I.PERKAL

Ceramic furnaces. I. ANON. *Trans. Sci.-Research Thermo-Technical Inst.*, 100 pp. (1932). State Energy Pub. House, Moscow-Leningrad. Price 2 R. 50 k. The papers deal with (1) the investigation of a gas producer plant in a glassworks using turf, (2) a description of a test of a Gross shaft furnace for calcining grog, (3) experiments in increasing the efficiency of Hofmann furnaces and lowering the fuel consumption, (4) investigations of an 18-chamber Hofmann furnace, and (5) experiments in a Hofmann furnace on the influence of the heating schedule on the quality of brick. S.I.PERKAL

Saggers for fine ceramics. D. S. CHOKOLOV. Ukrainian State Pub. House of Light Industry, Kharkov, 1933. 40 pp. Price 1 R. The requirements of saggers, their shape and sizes, raw materials necessary for their manufacture, components of the batches, and methods of molding, drying, firing, etc., are discussed. S.I.PERKAL

PATENTS

Furnace construction. L. H. HOSBEIN (M. H. Detrick Co.). U. S. 1,990,185, Feb. 5, 1935.

Interlocking fire brick for furnaces. A. J. PASSINO. U. S. 1,988,856, Jan. 22, 1935.

Method of glazing refractory bodies. R. F. RENNIE (Westinghouse Lamp Co.). U. S. 1,989,824, Feb. 5, 1935.

Wall with plastic refractory lining cooled by air circulation and method of constructing. G. F. SAINTENOY. Brit. 422,025, Jan. 16, 1935.

Terra Cotta

Changes in size of tile and brick on treatment with water. G. R. RIGBY. *Trans. Ceram. Soc.* [Eng.], **33** [11], 527–32 (1934); reprinted from *Bull. Brit. Refrac. Research Assn.*, No. 31 (June, 1933).—Changes in length were measured after subjecting commercial specimens of tile and brick to boiling water and steam. The unglazed tile and diatomite brick showed a definite increase in length, the glazed a negligible increase, while silica brick and fire brick gave a contraction. The expansion is explained on the basis of a chemical combination with water, and the decrease in length is ascribed to a surface tension effect of water. R.H.H.P., JR.

Mammoth jars. ANON. *Clay Prod. Jour. Australia*, **1** [3], 23 (1933).—The largest stoneware jar ever made on the potter's wheel in Australia has a liquid capacity of 100 gal., stands 4 ft. 3 in. high, is 3 ft. in diameter, and weighs 7½ hundredweight. It was made by Fowler's of Sydney. H.H.S.

Whiteware

De-airing gives new properties to pottery clays. ANON. *Ceram. Ind.*, **24** [2], 114–17 (1935).—From the potter's standpoint, the outstanding advantage of de-airing is the greater plasticity which it imparts to the body. De-airing accomplishes the same purpose as longer pugging or aging of the clay. Other advantages, depending upon the type of product, include reduction in warpage, denser bodies, reduced absorption, greater green strength, easier vitrification, and better workability of the body material. Illustrated. E.J.V.

Question box. ANON. *Trans. Ceram. Soc.* [Eng.], **33** [7], 251–59 (1934).—A symposium on mold making, slip casting, and glazes held by the pottery section is given. R.H.H.P., JR.

BOOK

Defects in Manufacture of Porcelain and Faience, Their Causes and Elimination. S. G. TUMANOV. State Chemico-Tech. Pub. House. Leningrad, 1934. 66 pp. Price 75 k. Eight basic groups of defects encountered in porcelain and faience manufacture are outlined. Causes of their origin are explained and methods of their elimination are given. Defects of saggers and semihydrated calcined gypsum molds are discussed briefly. S.I.P.

PATENTS

Closet bowl. GEORGE BRAIN (Standard Sanitary Mfg. Co.). U. S. 1,988,234, Jan. 15, 1935.

Domestic sanitary appliance. GUILLERMO ZORRAQUIN. U. S. 1,990,578, Feb. 12, 1935.

Drain pipe for flush tanks. F. P. HELLER. U. S. 1,989,859, Feb. 5, 1935.

Insulator. M. H. HUNT AND G. M. BARROW (Westinghouse Electric & Mfg. Co.). U. S. 1,987,683, Jan. 15, 1935. The method of coating a porcelain body comprises applying a liquid glaze material including a metallic oxide to a portion of the body in its unfired state, firing this body to vitrify the body and glaze material, and applying to a selected portion of the vitrified glaze, when cooled, a paste composed of constituents which react to produce nascent hydrogen which in turn reacts upon the glaze to reduce the metallic oxide.

Insulator for ignition plugs. H. NAVRATIEL. Brit. 422,474, Jan. 23, 1935.

Radio interference proof insulator. H. H. BROWN (Locke Insulator Corp.). U. S. 1,988,369, Jan. 15, 1935.

Equipment and Apparatus

Analysis of crushing and pulverizing processes. LINCOLN T. WORK. *Trans. A.S.M.E.* [R.P.-6], **55** (1933); abstracted in *Mech. Eng.*, **56** [2], 116 (1934).—Types of crushing and pulverizing mills are mentioned to show the diversity in operating characteristics. It is clear that different types of mills have been commercially adapted to similar products, and only rarely is one type of mill used to the exclusion of all others. The principles laid down illustrate the importance of grindability. A consideration of energy requirements shows a large waste of power over that needed to produce reduction in size. W.'s earlier work is confirmed on the difference in fineness-distribution curves produced under different grinding conditions and by different types of mills. Proper choice of mill, proper loading, and the application of separators offer the opportunity to produce material of specific-size characteristics or material below a given size at a minimum of cost. See also *Ceram. Abs.*, **13** [4], 95 (1934). F.G.H.

Apparatus for measuring viscosity coefficients in low temperatures. M. MAKOWIECKA. *Acta phys. Polon.*, **2**, 371–74 (1934); *Physik. Ber.*, **15** [23], 1995–96 (1934).—A modified Oswald capillary viscosimeter and its calibration are described. M.H.

Control of the packing of sand in shaking molding machines. G. DELCROISETTE. *Rev. fonderie moderne*, **28**, 327–28 (1934).—D. describes an apparatus which measures and checks whether the sand in the mold is packed in the manner prescribed for the particular kind of sand used. It consists of a small disk which penetrates into the sand by its own weight under the vibrations caused in the shaking process; the depth of penetration under defined conditions is a measure of the density of the packing of the sand. M.H.

Controlled-atmosphere furnaces and photoelectric pyrometers. H. A. WYNNE. *Ind. Heating*, **2** [1], 25–26 (1935).—Recent developments and some installations are described. M.H.

De-airing clayware. H. O. STEELE, B. T. BONNOT, J. H. CHAMBERS, AND H. I. JEFFREY. *Brick Clay Rec.*, **86** [1], 12–22 (1935).—A history of de-airing is presented with descriptions of the Steele, Bonnot, Chambers, and Fate-Root-Heath units by representatives of the manufacturers. Experimental and plant work that has been done is discussed and problems and future possibilities are considered. Illustrated. E.J.V.

Electric sieve. ALFONS SCHLOEMER. *Chem.-Ztg.*, **57** [69], 682–83 (1933).—This sieve is used for the separation of materials in the same way as mechanical sieves, except that the apparatus is good for handling grains of electrically nonconductive materials up to 2 mm. in diameter. The operation is as follows: as the material falls through the hopper it is attracted electrically by the shell; the smallest particles, moving faster than the others, reach the outlet first and go through the top outlet. The next larger particles fall a little longer way and go through the next outlet, etc. Illustrated. M.V.C.

Electrically heated furnace and its use in research on fired clay products. E. H. COLEMAN. *Trans. Ceram. Soc.* [Eng.], **33** [8], 321–30 (1934).—The construction of an electrically heated furnace designed to investigate the durability of heavy ceramic ware and characterized by ease of control of atmosphere is described. Uniformity of heating was tested by examining statistically values of crushing strength, absorption, and soluble salt content of fired specimens. R.H.H.P., JR.

Electromagnetic separators and extractors for treating all classes of pottery, refractories, and builder's material. W. E. BOX. *Trans. Ceram. Soc.* [Eng.], **33** [9], 352–67 (1934).—The industrial applications of a number of improved magnetic separators are discussed. Illustrated. R.H.H.P., JR.

Enamel spray booth efficiency. FRANK R. PORTER. *Ceram. Ind.*, **24** [2], 118 (1935).—Illustrated. E.J.V.

Highly heat-resisting chromium-aluminum-iron alloys. A. GRUNERT, W. HESSENBRUCH, AND K. SCHICHTEL. *Elektrowärme*, **5** [1], 2–11(1935).—A thorough investigation of Cr-Al-Fe alloys showed a decided superiority of their properties over those of the Cr-Ni alloys, especially in oxidizing atmospheres and those containing C and S. Their different fine structure is less sensitive at the grain boundaries where corrosion usually starts. Above 1200°C they should be used instead of the Cr-Ni alloys in industrial furnaces with normal oxidizing atmospheres. Examples show how to choose between Cr-Ni and Cr-Al-Fe alloys for temperatures below 1200°C. M.H.

Measuring liquids with drum-meters. F. GERHART. *Siemens-Z.*, **14** [11], 375–78 (1934).—A meter consisting of a rotating drum which fills and discharges continuously and automatically is described; liquids of greatly varying viscosity can be measured. The meter can be connected with a device which automatically takes samples of the passing liquid for analysis or supervision. M.H.

Pipette method in the fineness test of molding sand. CLARENCE E. JACKSON AND C. M. SAEGER, JR. *Jour. Research Nat. Bur. Stand.*, **14** [1], 59–67 (1935); R.P. 757. Price 5¢.—Details of the development and use of the pipette method in the fineness test of molding sands are outlined. The method of computation and scope of results are shown by typical examples. A rapid method suitable for foundry control work and routine testing is suggested. R.A.H.

Pressure feed tank ideal for use with porcelain enamel. G. H. BUZZARD. *Enamelist*, **12** [5], 21–22 (1935).—Specifications are given. Illustrated. E.J.V.

Scientific drying of clay products. N. P. HUNT. *Clay Prod. Jour. Australia*, **1** [1], 21–24 (1933).—The methods of air conditioning or "manufacturing weather" are described. For each type of clay product there is an optimum combination of air motion, temperature, and humidity. Curves of drying rate efficiency are given. The amount of floor space used can be reduced by suitable equipment. H.H.S.

Stage pressing to remove air in a hydraulic dry press. BENJAMIN LASSMAN. *Brick Clay Rec.*, **86** [1], 32 (1935).—A description of stage pressing in which the press moves through four pressing cycles or stages and pressures up to 5500 lb. are developed is given. E.J.V.

Streamlined pugging knives keep air out of clay. H. R. STRAIGHT. *Brick Clay Rec.*, **86** [1], 22 (1935).—A pugging knife so streamlined as to prevent the pumping or lapping

in of air by the movement of the knives through the clay is announced. A special alloy has been developed which gives them a life equivalent to pugging 135,000 tons of ordinary clay. Illustrated. E.J.V.

Suspension turbidimeter for determining specific surface of granular materials. ALEXANDER KLEIN. *Proc. A.S.T.M.*, **34** [Part II], 303–21 (1934).—K. describes a portable apparatus for rapid determination of the surface area of Portland cement and other granular materials in which the turbidity of a suspension of the material in castor oil is measured. The method does not involve Stokes' law which is the basis of sedimentation methods, but consists in determining the mean effective cross-sectional area of the suspended material under static conditions through the use of photoelectric equipment. Hence, no consideration of time or velocity is involved in the determinations, no standard samples are required, and the method is independent of the physical characteristics of the suspending medium. A theoretical constant required for the analysis of a given material is determined from an observation on a sieved sample of the material itself. A high degree of reproducibility is attained, and the method appears to furnish an accurate measure of the relative fineness of the various materials. Comparisons are made between test results obtained by means of this apparatus and by means of apparatus employing the principle of sedimentation. R.A.H.

Technical testing of materials with X-rays. FRITZ KÄSTNER. *Messtechnik*, **10** [8], 141–45 (1934).—A review of the progress made is given and some apparatus are described. M.V.C.

Temperature measurement up to 5500°C with particular consideration of the platinum-hard glass thermometer. W. GOEDECKE. *Elektrowärme*, **4** [12], 278–81 (1934).—A comparison of the thermoelectric method with the resistance method of temperature measurement showed the superiority of the resistance thermometer. A special construction of a Pt thermometer is described in which the Pt wire is melted into a glass of high melting point. The error of such instrument is about ±0.5% for 2 measuring wires in the glass and ±0.15% for one wire. M.H.

Vane calorimeter. R. W. CARLSON. *Proc. A.S.T.M.*, **34** [Part II], 322–28 (1934).—C. describes a calorimeter used for measuring heat of hydration of neat-cement pastes while curing at substantially constant temperature. Typical data are presented with diagrams showing the hourly rates of heat evolution for a number of cements plotted against the time after mixing. Comparison of results with those from the heat-of-solution calorimeter indicate that satisfactory accuracy is obtained using the vane calorimeter. R.A.H.

BOOKS

Driers in the Porcelain-Faience Industry. D. S. CHOKOLOV. State Pub. House of Light Industry, Leningrad-Moscow, 1934. 68 pp. Price 1 R. The subject of this brochure is outlined under the following headings: (1) heat and humidity absorption, (2) object of drying and phenomena taking place in this process, (3) establishment of drying schedules, (4) basic principle of the work of driers, (5) modern systems of driers and their peculiarities (short descriptions of driers for gypsum molds and data on drying saggers are given), (6) causes of spoiled ware and how to eliminate them, and (7) brief instruction on how to work at driers. S.I.PERKAL

Short introduction to the use of the polarization microscope (Kurze Einführung in den Gebrauch des Polarisations-Mikroskops). FRITZ KÄSTNER. Müller and Schmidt, Coburg, 1934. 91 pp. Price 4.90 Rm. M.V.C.

PATENTS

Air nozzle for flat-spraying appliances. ERIC GUSTAFSSON (Binks Mfg. Co.). U. S. 1,990,824, Feb. 12, 1935.

Apparatus for ascertaining the plasticity of materials. ENOCH KARRER (B. F. Goodrich Co.). U. S. 1,988,597, Jan. 22, 1935.

Brick stack carrying trailer. R. A. FONTAINE. U. S. 1,986,926, Jan. 8, 1935.

Dies and presses for manufacturing pottery articles. J. BOURNE & SON, LTD., AND W. COULTER. Brit. 422,038, Jan. 16, 1935.

Gloss-measuring device. R. S. HUNTER (Henry A. Gardner). U. S. 1,988,556, Jan. 22, 1935.

Ware handling and transfer mechanism. H. A. MOORE AND C. A. NIELSEN (Amco, Inc.). U. S. 1,990,745, Feb. 12. 1935. Ware-transferring mechanism comprises a ware delivering device and an escalator buck for receiving the ware.

Kilns, Furnaces, Fuels, and Combustion

Automatic stoker for downdraft kilns. ANON. *Brit. Clayworker*, **43** [513], 283–84 (1935).—A detailed description with photograph and line drawing is given of this stoker intended to prevent smoking of the kilns with which it is used. R.A.H.

Carder tunnel oven. S. R. HIND. *Trans. Ceram. Soc.* [Eng.], **33** [7], 274–97 (1934); reprinted from *Bull. Brit. Refrac. Research Assn.*, No. 21 (Sept., 1929).—Tests of the performance of a continuous Carder tunnel kiln firing stoneware jars and bottles are summarized in a heat balance. A lower rate of fuel consumption represents a saving of about 75% over round-kiln practice. Illustrated. R.H.H.P., JR.

Draft-pressure factor in heat distribution. ELLIS LOVEJOY. *Bull. Amer. Ceram. Soc.*, **14** [2], 93–95 (1935).

Effect of reradiation on heat transmission in furnaces and through openings. H. C. HOTTEL AND J. D. KELLER. *Trans. A.S.M.E.* [*Iron & Steel*-6], **55**, 39–49 (1933); abstracted in *Mech. Eng.*, **56** [2], 114–15 (1934).—In heat transmission by radiation, the reradiation of heat from adjacent surfaces has been a perplexing question, *e.g.*, radiation of heat through openings in furnace walls and in electric furnaces having heating elements under the roof only. Accurate methods of calculation are developed, and curves from which the reradiation and total radiation factors can be read at a glance are presented for various

shapes and proportions of radiating surfaces or openings. Two methods of solving integral equations are presented. The theoretically developed values are checked and substantiated by actual test measurements. F.G.H.

Electric radiation furnaces. HENRI GEORGE. *Rev. fonderie moderne*, **28**, 337–42 (1934).—Electric furnaces with carbon (graphite) resistances are used particularly for producing very high temperatures rapidly; 2700°C could easily be reached. Furnaces up to 300 kw. and a current density of 500 amp./cm.^{2} in the graphite resistance are described in which Si ingots were made in 6 min. starting from cold and going up to 2000°C. M.H.

Factors affecting furnace heating practice. II. R. J. SARJANT. *Trans. Ceram. Soc.* [Eng.], **33** [9], 331–51 (1934).—Data exist for the solution of any problem concerned with draft losses in furnace systems, provided the condition of the surfaces and the configuration of the flue system is known. The rate of heat absorption of the refractories under fluctuating gas flow can be calculated, as well as the heat transmission by radiation and convection from nonluminous gases. The necessary formulas are presented and the methods of estimation are explained. For Part I see *Ceram. Abs.*, **12** [10–11], 358 (1933). R.H.H.P., JR.

Heating element technique in industrial furnaces. L. MOENNICH. *Elektrowärme*, **5** [1], 15–17 (1935).—Materials at present available for heating elements of electric industrial furnaces are reviewed, especially for temperatures up to 1350°C for which alloys of Cr, Al, and eventually Co are employed. The influence of these materials on furnace design is discussed, and the longer life of furnaces and heating elements is pointed out. M.H.

Heat-transfer design data and alignment charts. T. C. CHILTON, A. P. COLBURN, R. P. GENERAUX, AND H. C. VERNON. *Trans. A.S.M.E.* [*Petroleum Mech. Eng.*-2], **55** (1933); abstracted in *Mech. Eng.*, **56** [1], 58 (1934).—During a research program on heat transfer, the best available methods for the prediction of heat-transfer coefficients and for simplifying design calculations were sought. The equations selected or developed on film coefficients are given for gases flowing in turbulent motion inside tubes, for gases flowing across tube banks, for free convection outside horizontal cylinders and at vertical surfaces, and for condensing vapors. Alignment charts are given for the solution of these equations. A simplified method of designing gas-heat exchangers was worked out on the basis of one of the equations for the heat-transfer coefficient, and a chart is given for pressure-drop calculations made in designing heat-transfer equipment. F.G.H.

Industrial gas heating. PETER LLOYD. *Gas Jour.*, **205**, 557–60, 622–24 (1934); *Gas World* [*Ind. Gas Supp.*], **100** [2589], 23–29.—Industrial gas-heating operations are classified. The importance and determination of thermal efficiency are discussed and illustrated with examples. Special emphasis is laid on heat losses, and equations for their calculation are given. (*C.A.*)

Kiln installation. J. B. NEALEY. *Ind. Heating*, **2** [1], 43–46 (1935).—The installation of a ring-type tunnel kiln for bisque and glost firing, circular-type driers, and a straight tunnel-type decorating kiln is described in detail. M.H.

Maximum load for Silit heating elements. H. FRIEDRICH. *Elektrowärme*, **4** [12], 274–75 (1934).—The obtainable temperatures in the furnace or in the material to be heated for the maximum permissible temperature of the Silit heating element were experimentally determined.

Furnace or material temperature (°C)	Heating element surface load (watt/cm.^{2})	Overtemperature (°C)	Heating element temperature (°C)
1000	30	450	1450
1100	26	350	"
1200	21	250	"
1250	17	200	"
1300	13.5	150	"
1350	9	100	"
1400	4.6	50	"

Suggestions for proper selection of surface load and arrangement of the heating elements are discussed. M.H.

Semiluminous flame obtained with heavy domestic fuel oil in a specially designed furnace. P. L. MIKESKA. *Trans. A.S.M.E.* [*Petroleum Mech. Eng.*-3], **55** (1933); abstracted in *Mech. Eng.*, **56** [1], 58 (1934).—Advantages of the semiluminous flame and the mechanics involved in obtaining it for oil-burning furnaces are discussed in detail. F.G.H.

Solid and liquid fuels. L. LAHOUSSEY AND LEDUC. *Usine*, **43** [47], 35–37 (1934).—The characteristics of solid and liquid fuels now mainly used in industrial heating are discussed with respect to purchasing price, particular advantage of each fuel, and utilization of national domestic supplies as determining factors for their selection in a given case, with special application to French conditions. M.H.

Waste-gas chimneys of double-walled clay pipes. E. SCHUHMACHER. *Gas & Wasserfach*, **77** [46], 797–98 (1934).—Clay pipes glazed on the inner surface are a better material for waste gases, especially hot gases, than brick as the latter have more mass and therefore absorb more heat, are easily destroyed by condensates, and are not very dense. Double walls permit air cooling and heat insulation by the air in the space between the two walls. Experiments have given good results; these pipes have been used as chimneys of domestic gas furnaces. M.H.

PATENTS

Brick kiln arch and means and method for producing. A. C. LUTTER (Lutter Brick Co.). U. S. 1,990,832, Feb. 12, 1935.

Continuous kilns for firing brick, terra cotta, etc. J. SHERLOCK. Brit. 422,424, Jan. 23, 1935.

Continuous tunnel kiln and method of operating. PHILIP DRESSLER (Swindell Dressler Corp.). U. S. 1,988,837, Jan. 22, 1935.

Geology

Anhydrite-gypsum problem of Blaine Formation, Oklahoma. J. Lawrence Muir. *Bull. Amer. Assn. Petroleum Geol.*, **18** [10], 1297–1312 (1934).—A study was made of the three gypsum and anhydrite beds of the Blaine Formation (Medicine Lodge, Shimer, and Lovedale) which outcrop at Salt Creek Canyon, Blaine County. The evidence is that the gypsum has formed slowly near the surface by hydration of the anhydrite with no volume increase and that the anhydrite was probably the primary precipitate in a desiccation basin, being deposited in a hot, dry climate. G.M.H.

Boehmite and diaspore in the fire clays of Ayrshire (Scotland). J. de Lapparent. *Compt. rend.*, **199** [26], 1629–31 (1934).—Stratification and geological conditions of the extensive deposits of fire clay are described in which crystals of boehmite, AlO_2H, are widely distributed. Diaspore is found in the boehmitic parts in clearly discernible crystals of bauxitic character; in general the whole deposit is similar to bauxite. M.H.

Crystal structure and swelling of montmorillonite. U. Hofmann, K. Endell, and D. Wilm. *Z. Krist.*, **86** [5–6], 340–48 (1933).—Analyses and interference of montmorillonite (the clay mineral of the bentonite clays) and bentonite are shown in tables. Montmorillonite is orthorhombic with $a = 5.095$, $b = 8.83$, and $c = 15.2$ Å. The structure consists of layers of double SiO_4 sheets, with the free oxygen atom of each SiO_4 tetrahedron toward the center. The Al ions and OH groups are between the SiO_4 sheets. The swelling with water is one-dimensional and reversible. The distance between layers varies from 19.6 Å with over 30% water to 9.6 Å when heated to 550° (4.6% H_2O). The structurally similar pyrophyllite does not swell with water. G.R.S.

Lithium in the ceramic industry. V. Charrin. *Céram., Verrerie, Email.*, **2** [7], 305–306 (1934).—Lepidolite, a lithium-bearing mica, may be used in glass batches to increase the fluidity and lower the coefficient of expansion. In porcelain it produces extreme whiteness and makes the product more resistant to thermal shock. The physical properties and composition of lepidolite and other lithium-bearing minerals are given. M.H.B.

Microscopic testing of ceramic raw materials. Fritz Kästner. *Sprechsaal*, **67** [45], 685–88 (1934).—Directions for using petrographic microscopes for investigating quartz, kaolin, and clay are given. Tables with data on feldspars and heavy liquids for separations and a literature index are given. M.V.C.

Quartzites of Poltava district, especially those of Ocheretino deposits. P. P. Budnikoff. *Mineral. Suir'e*, **8** [5], 20–26 (1933); abstracted in *Chem. Zentr.*, ii, 653 (1934).—The chemicophysical and microscopic analyses of the quartzites show that they are suitable for the production of Dinas brick for Martin furnaces and coke ovens. See also *Ceram. Abs.*, **13** [1], 14 (1934). M.V.C.

Röntgen analysis of minerals in the earth's crust. J. M. Bijvoet and W. Nieuwenkamp. *Chem. Weekblad*, **31** [49], 740–47 (1934).—The crystal chemistry of silicates is discussed and atomic models of minerals most frequently occurring in the earth's crust are developed. M.H.

Separating the clayey fraction of sedimentary rocks. M. Dreyfuss. *Compt. rend.*, **199** [26], 1631–33 (1934).—Clay in rocks, even if present in very small amounts, is separated by deflocculation in (*a*) 2% potassium soap solutions, (*b*) 1% gum arabic solutions, and (*c*) ¼% gelatine solutions. Exact directions are given. M.H.

X-ray investigation of clays. I. X-ray diagrams of some clay minerals. II. Mineral composition of clay from Malliss. G. Nagelschmidt. *Z. Krist.*, **87** [1–2], 120–45 (1934).—Powder photographs were made of nacrite, dickite, kaolinite, halloysite, montmorillonite, quartz, muscovite, and calcite. Detailed descriptions and measurements of the photographs are given. Clay from Malliss, Mecklenburg, was centrifuged into five fractions from less than 0.05 μ up to 30 μ. The distribution of the constituent minerals was determined by X-ray data and checked by chemical analysis. Quartz and calcite increase and kaolinite and muscovite decrease in the coarser fractions. G.R.S.

X-ray investigation of feldspars. W. H. Taylor, J. A. Darbyshire, and H. Strunz. *Z. Krist.*, **87** [6], 464–98 (1934).—Orthoclase, hyalophane, and celsian have identical structures, being monoclinic. The difference between albite and orthoclase structures is what might be expected to result from replacement of potassium by sodium. Measurements on labradorite and anorthite show that the calcium-rich plagioclases are based on a unit cell twice the size of the albite unit cell. The structure accounts in detail for the cleavage and twinning of feldspars. The results suggest that the potassium, potassium-barium, and barium feldspars constitute an isomorphous series of crystals which are structurally monoclinic. In this series the barium ion can replace the potassium ion without disturbing the tetrahedron framework to any appreciable extent, and as the barium content increases there is random replacement of increasing numbers of potassium ions. The potassium-sodium feldspars do not form truly homogeneous crystals, if the amount of sodium present is fairly large, but assume lamellar structures of perthite type and of varying degrees of fineness. The tetrahedron framework may be quite continuous throughout the entire crystal but is modified locally according to whether the region is rich in potassium or rich in sodium, reproducing the orthoclase and albite structures, respectively. In this group the X-ray results confirm the optical evidence for the existence of a nonhomogeneous crystal complex. 27 references. G.R.S.

BOOKS AND BULLETINS

Alkalinity of silicate minerals. R. E. Stevens. *Geol. Surv. Prof. Paper*, 185-A, 13 pp. Price 5¢. For abstract see *Ceram. Abs.*, **12** [10–11], 395 (1933). R.A.H.

Bibliography and Index of Geology Exclusive of North America, Vol. I (1933). John M. Nickles and Robert B. Miller. Geol. Soc. Amer. Bibliographic Contributions, 1934. 405 pp. Reviewed in *Bull. Amer. Assn. Petroleum Geol.*, **18** [10], 1379 (1934). G.M.H.

Clay. Paul M. Tyler and R. W. Metcalf. Reprint from U. S. Bur. Mines Minerals Yearbook, 1934 (*Ceram. Abs.*, **14** [2], 51 (1935)). 14 pp. Price 5¢. R.A.H.

Compilation of Official Geological Studies in Colombia—

1917 to 1933, Vol. I (Compilacion de los Estudios Geologicos Oficiales en Colombia). ROBERTO SCHEIB. Edited by George A. Perry, Chief Engineer, Tech. Div., Dept. Mines and Petroleum. Published by Jefe de la Sección de Publicaciones, Belisario Vejarano S., Bogatá, Colombia. Imprenta Nacional, 1933. 475 pp., 79 figs., 9 maps in pocket. Mentioned in *Bull. Amer. Assn. Petroleum Geol.*, **18** [10], 1377–78 (1934). G.M.H.

Geological Map of Republic of Austria and Neighboring Territory. Compiled by HERMANN VETTERS. Geologische Bundesanstalt, Vienna III, Rasumofskygasse 23. Price 60 schillings. Reviewed in *Bull. Amer. Assn. Petroleum Geol.*, **18** [10], 1375–77 (1934). G.M.H.

Geophysical prospecting abstracts. F. W. LEE. *Bur. Mines Periodical Service Rept.*, G.A. 67, 21 pp. Price 10¢. See also *Ceram Abs.*, **14** [3], 81 (1935). R.A.H.

Halloysite and allophane. C. S. ROSS AND P. F. KERR. *Geol. Surv. Prof. Paper*, 185-G, 13 pp. Price 5¢. The study of the kaolin minerals, of which kaolinite, dickite, and nacrite were described in *Professional Paper* 165-E (*Ceram. Abs.*, **11** [1], 56 (1932)) is continued. Halloysite is closely related to but distinct from kaolinite and is apparently always the result of weathering like kaolinite, whereas dickite and nacrite are commonly the result of hydrothermal processes. Allophane is described as an amorphous material that is commonly associated with halloysite. R.A.H.

Zones in Alberta shale ("Benton Group") in foothills of southwestern Alberta. J. B. WEBB AND LEO GEORGE HERTLEIN. *Bull. Amer. Assn. Petroleum Geol.*, **18** [11], 1387–1416 (1934).—The Alberta shale zones are very useful in mapping structure and in correlating in the foothills belt of Alberta. The authors give lithological and paleontological descriptions of the various zones. G.M.H.

Chemistry and Physics

Adsorption of water-vapor by magnesium oxide. F. ISHIKAWA AND K. SANO. *Sci. Repts. Tohoku Imp. Univ.*, **23** [1], 129–38 (1934).—Magnesium oxide first adsorbs aqueous vapor, and the adsorption equilibrium is attained before the hydration of the oxide, the latter process proceeding quite slowly compared with the adsorption process. The velocity of the adsorption of aqueous vapor in air by magnesium oxide was studied. The adsorption isotherm at 51°C may be represented by Freundlich's formula. The relation between adsorbed quantity, pressure, and temperature was investigated. The linearity was established between log P/aT and $1/T$ in the temperature range from 9 to 42°C. W.M.C.

Basic salts. III. Equilibria in the system CuO–Cr_2O_3–H_2O. ERICH HAYEK. *Z. anorg. allgem. Chem.*, **216** [3], 315–20 (1934).—CuO was shaken with a $CuCrO_4$ solution at 40° until constant conductivity was attained. Two compounds were identified in the system microscopically and by X-rays: $2CuCrO_4 \cdot 3Cu(OH)_2 \cdot H_2O$ and $CuCrO_4 \cdot Cu(OH)_2$. L.T.B.

Crystal models demonstrate arrangement of molecules in space. H. A. STUART. *Z. tech. Physik*, **15** [12], 566–67 (1934).—Illustrated. W.M.C.

Dependence of the equilibrium $FeO + Ni \rightleftharpoons NiO + Fe$ in melt with SiO_2 additions. III. Communication on equilibrium between metal, sulfides, and silicates in melt. WILHELM JANDER AND HANS SENF. *Z. anorg. allgem. Chem.*, **217** [1], 48–52 (1934).—Authors determined (1) the change in equilibrium with increasing SiO_2 and (2) the dependence of equilibrium on temperature (1450–1660). It was found that K_H decreases as SiO_2 increases to 12%. Above 12% K_H is constant. The decrease in K_H observed may be due to combination of FeO and SiO_2. The following relation was found to express the dependence of K_H on temperature: $\log K_H = -(6300/T) + 1.29$. L.T.B.

Determining size of ultramicrons with interference microscope. ARTUR KLIMMECK. *Z. Physik*, **85** [1], 68–84 (1933).—A short introduction shows the application of the principles of the Michelson interferometer to the microscope. In the most recent applications the distance between the interferometer slits is varied whereby measurement is simplified. If azimuthal blinds are not used a certain form factor arises which is dependent on the form of the object and the intensity of the light distribution on it. K. succeeded in determining the factor as long as the particle did not lie below the resolution power of the objective. Particles were measured to 200 $\mu\mu$ diameters. The procedure is limited by the numerical aperture of the objective. The apparatus is described and experimental data are given in detail. L.T.B.

Effect of rate of cooling on structure of eutectics. G. TAMMANN AND G. MORITZ. *Z. anorg. allgem. Chem.*, **214** [4], 414–26 (1933).—By cooling eutectics slowly the structure tends to become granular; by more rapid cooling, it becomes needlelike. On undercooling eutectics slightly, the crystals are small with many faces developed; on undercooling considerably, needles grow whose ends lie in a plane perpendicular to the axis of the needle. The dependence of the rate of crystallization, which is a vector quantity, was studied in eutectics and chemically homogeneous materials by measurement of the heat of crystallization. The following facts were determined: (1) The ends of the crystal needles of a polynary eutectic lie in a plane. (2) On rapid crystallization the needles of a eutectic become smaller and thinner, even submicroscopic. (3) In a binary eutectic in a plane perpendicular to the needle axis, the needle cross-sections are not at random, but one type of crystal surrounds the other. (4) The rate of crystallization of a eutectic is slower than the slowest rate of its constituents. The needle structure of a eutectic can be appreciably changed by shrinkage of its needles. If a eutectic is heated to a temperature close to the melting point of the eutectic, the needles become thicker and shrink. The closer the temperature to the melting temperature of the eutectic, the more rapid is the shrinking. Shrinking begins when the surface tension becomes greater than the force of tension on the needles. A practical study was made on a series of metallic eutectics. L.T.B.

Feldspar analysis. H. B. KNOWLES AND J. C. REDMOND. *Jour. Amer. Ceram. Soc.*, **18** [3], 106–12 (1935).

Line spectrum of chromic oxide and absorption spectrum of chromium glasses. G. JOOS AND K. SCHNETZLER. *Z. physik. Chem.*, **B24** [5–6], 389–93 (1934).—Pure Cr_2O_3 at −190° shows five indistinct lines in the absorption spectrum which do not depend on the method of preparation of the compound but are characteristic of the Cr_2O_3-lattice. Cr_2O_3 is not soluble in B_2O_3, but the lines of both compounds remain in melts of mixtures of these compounds. On the addition of alkalis to B_2O_3–Cr_2O_3 mixtures, the lines characteristic of Cr_2O_3 disappear with increasing alkali content; otherwise the absorption spectrum retains the character of the spectrum of an aqueous solution in spite of the very low temperature. Apparently the Cr_2O_3 lattice is not destroyed. The fact that no new lines appear in the spectrum of the glass indicates that the glass has no structural periodicity. L.T.B.

Reactions in the solid state. WILHELM JANDER. *Angew. Chem.*, **47** [16], 235–38 (1934).—J. reviews the theory of reactions in the solid state. Reactions in the solid state do not proceed simply by the addition of the components to form the final products; rather the components show an increased catalytic activity as evidenced by magnetic, surface, and volume changes which point to intermediate amorphous or pseudo-amorphous products before the final reaction is consummated. The theory is based on studies of reactions by various investigators between CaO and SiO_2, Al_2O_3, or Fe_2O_3. See also "Thermal—," *Ceram. Abs.*, **13** [5], 132 (1934). L.T.B.

Sodium carbonate decomposition. E. PRESTON AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **18** [71], 182–93 (1934).—Decomposition studies of Na_2CO_3 were made at temperatures from 650 to 1100°C when heated in air and in a stream of water-vapor. In contrast to the decomposition in an evacuated system where an incipient dissociation was reported at approximately 980°C, the commencement of decomposition in air was detectable after heating for one day at 400°C, and became appreciable at 800°C. This decomposition in air is regarded as due to reaction between the water-vapor of the atmosphere and Na_2CO_3, resulting in the formation of free sodium hydroxide. At 800° the equilibrium was approximately 97.5% Na_2CO_3 and 2.5% NaOH, although these figures were largely dependent on the mass and depth of charge and the adsorbed water-vapor within the mass of the material. At 800° the amounts of NaOH produced by heating in a stream of water-vapor were about three times as great as in the case of specially dried samples at the same temperature. For obtaining dry Na_2CO_3 a satisfactory heating temperature was given as 400°C. A.A.

Sodium fluosilicate obtained from hydrofluoric acid, quartz, and sea salt. I. G. RUIS. *Zhur. Khim. Prom.*, **10** [3], 48–52 (1934); abstracted in *Chim. & ind.*, **32** [4], 863 (1934); *Chem. Zentr.*, **ii**, 3158 (1934).—The possibility of obtaining sodium fluosilicate by passing HF through a filter with sand and the precipitation of concentrated solutions of fluosilicic acid with sea-salt solutions were studied. The precipitate contains from 96 to 98% sodium fluosilicate after washing by decantation and drying. Details are given. M.V.C.

System Na_2O–B_2O_3. III. Optical properties, X-ray patterns, and melting points of anhydrous sodium borates. S. S. COLE, N. W. TAYLOR, AND S. R. SCHOLES. *Jour. Amer. Ceram. Soc.*, **18** [3], 79–81 (1935). **IV. Vapor pressures of boric oxide, sodium metaborate, and sodium diborate between 1150°C and 1400°C.** S. S. COLE AND N. W. TAYLOR. *Ibid.*, pp. 82–85 (1935). For Parts I–II see *Ceram. Abs.*, **14** [3], 83 (1935).

Viscosities of the binary systems $Na_2B_4O_7$–B_2O_3 and $NaBO_2$–$NaPO_3$ in the fused state. M. P. VOLAROVICH AND D. M. TOLSTOI. *Jour. Soc. Glass Tech.*, **18** [71], 209–21 (1934); for abstract see *Ceram. Abs.*, **10** [11], 807 (1931); **13** [4], 102 (1934). A.A.

Viscosity of the binary system $Na_2B_4O_7$–NaH_2PO_4 in fused state. M. VOLAROVICH. *Jour. Soc. Glass Tech.*, **18** [71], 201–208 (1934).—Viscosities of $Na_2B_4O_7$–NaH_2PO_4 mixtures were determined from 527 to 920°C, employing a rotating cylinder viscometer. The viscosity of fused borax ranged from 3.30 poises at 880° to 83,750 at 590°, and the viscosity of NaH_2PO_4 from 2.83 poises at 863° to 65.9 at 527°. Of the four mixtures studied, the viscosities of 75% and 87.5% $Na_2B_4O_7$ were practically the same as that of $Na_2B_4O_7$ itself. For a mixture containing 75% NaH_2PO_4, 25% $Na_2B_4O_7$, the values were 15.7 poises at 732° and 38,370 at 532°. There was no indication of the formation of any intermediate complex compounds. A.A.

Volatility of silica. E. PRESTON AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **18** [71], 222–24 (1934).—Fused transparent silica disks showed no loss in weight when heated in air for 20 hr. at 1400°C. Similar disks when subjected to the action of steam showed a loss in weight which was negligible when heated for 20 hr. at 1300°C but which was appreciable although small when heated at 1400°C for 20 hr. or at 1500°C for 4 hr. The surface of the disks heated in the presence of steam became slightly pitted and glossy. A.A.

X-ray back-reflection method for measuring elastic strain. H. MÖLLER. *Arch. Eisenhüttenwesen*, **8**, 213–18 (1934).—The application of this method for strain analysis is demonstrated, the main advantage being that the sample is not destroyed by the test. See also *Ceram. Abs.*, **12** [10–11], 385 (1933). W.M.C.

X-ray investigation of MgZn and $MgZn_2$. L. TARSCHISCH. *Z. Krist.*, **86** [5–6], 423–38 (1933).—X-ray data prove the existence of MgZn whose structure resembles that of $MgZn_2$. The latter has a hexagonal unit containing 4 mol. (4Mg + 8Zn). A similar unit for MgZn, with $a = 5.33$ and $c = 8.58$ Å, contains 6 mol. (6Mg + 6Zn) but contains weak reflections indicating that the true unit cell should be doubled. For $MgZn_2$, $a = 9.92$, $c = 16.48$ Å, with 16 mol. Density is 6.60. Both structures consist of alternating layers of Mg and Zn atoms. G.R.S.

BOOK

Colloid Chemistry. A. W. THOMAS. McGraw-Hill Book Co., New York. 512 pp. Price $4.00. *Mining & Met.*, **16** [338], 5 (1935).—Colloid chemistry is treated from the viewpoint of crystalloidal chemistry instead of from the physical viewpoint, and colloid interactions are accounted for on a simple crystalloidal basis. Bicolloids as well as inorganic dispersions are covered. Fundamental techniques of colloid chemistry are discussed. E.J.V.

PATENTS

Chlorinated alkaline silicate. PAUL LOGUE AND W. N. PRITCHARD, JR. (Swann Research, Inc.). U. S. 1,989,759, Feb. 5, 1935. The method of producing a detergent consists in combining sodium silicate with caustic soda to obtain a product having a ratio of Na_2O to SiO_2 between the limits of 1 to 1 and 2 to 1, kneading the composition to form dry granules, incorporating trisodium phosphate into the granular mass, exposing the composition while in a dry state to the action of chlorine gas, and coating the chlorinated product with oleic acid.

Decomposition of siliceous aluminiferous minerals. T. GOLDSCHMIDT AKT.-GES. Brit. 422,463, Jan. 23, 1935.

Production of base exchange materials. O. C. RALSTON AND K. M. BAUM (Arizona Minerals Corp.). U. S. 1,990,751, Feb. 12, 1935. The method of preparing an artificial zeolite comprises mixing solutions of sodium aluminate and sodium silicate under conditions of thorough agitation to form a precipitate in fluid suspension, and subjecting the resulting product to a low-temperature drying operation.

Sodium metasilicate detergent. H. V. MOSS AND F. D. SNELL (Swann Research, Inc.). U. S. 1,989,765, Feb. 5, 1935. A method of producing a detergent consists in providing a sodium silicate solution, adding caustic soda thereto, agitating and heating the solution to evaporate water therefrom and to yield a solution of sodium metasilicate, cooling and kneading the solution to form a plastic mass, further cooling with disintegration to form a solid product, pulverizing the product, agitating the pulverized product, and spraying it with a higher fatty acid while agitating to form a soap film over the surfaces of the particles.

General

Acceptance-rejection requirements in specifications. H. F. DODGE. *Proc. A.S.T.M.*, **34** [Part II], 877–90 (1934).—For many characteristics, 100% inspection is not feasible, hence reliance must be placed on sampling a part of the whole. Under these conditions, 100% conformance with requirements can not be achieved with certainty and errors arising from sampling fluctuations can not be avoided. The sampling clauses included in specifications often provide criteria for the acceptance or rejection of lots of a product. These clauses constitute interpretations of the intent of the basic quality requirements and serve as basis for action. With sampling, certain risks are assumed by both the consumer and the producer. One kind of risk is discussed and the relation between (1) the distribution of the risk between producer and consumer and (2) the choice of acceptance criteria and sample size is indicated for certain conditions. R.A.H.

Ceramic education in Australia. ANON. *Clay Prod. Jour. Australia*, **1** [12], 29; **2** [1], 17 (1934).—Brisbane, Queensland, was the first city in Australia to start classes for pottery workers. Sydney, N.S.W., followed soon after. H.H.S.

Dewatering clay suspensions by spray evaporation. HEWITT WILSON, GEORGE A. PAGE, AND VANCE S. CARTWRIGHT. *Ceram. Ind.*, **24** [2], 126–28 (1935).—By spray evaporation the process of dewatering is reduced to one step instead of three. Experiments indicated that the best type of atomizer for clay suspensions was the centrifugal sprayer. Details of the construction and operation of the Page centrifugal spray evaporator and the Bowen spray process are given. E.J.V.

English pottery progress. J. SHORTER. *Clay Prod. Jour. Australia*, **1** [12], 21–22 (1934).—Revisiting England after six years S. believes that there has been more improvement in manufacturing methods in those six years than in the preceding fifty. H.H.S.

Mellor Laboratories. ANON. *Pottery Gaz.*, **60** [691], 69–71 (1935).—The Mellor Laboratories at Shelton, Stoke-on-Trent, the new research laboratories of the British Refractories Research Assn., are described. Illustrated. E.J.V.

Porosity. C. R. F. THRELFALL. *Trans. Ceram. Soc.* [Eng.], **33** [8], 299–320 (1934).—A study of the mechanics of porosity indicates that low porosity brick fired short of vitrification have greater strength, hardness, slag resistance, and spalling resistance. The quality of high grog brick varies inversely as the porosity. Careful grading of materials with increased maximum grain sizes and closer packing of the particles made possible by shaking the mixes tends to lower the firing temperatures and make less important the process of de-airing. Other factors such as lamination and making faults which contribute toward porosity should be eliminated. R.H.H.P., JR.

Presidential Address for 1934–1935. W. KEITH MCAFEE. *Bull. Amer. Ceram. Soc.*, **14** [2], 72–75 (1935).

Pyrometric cone equivalent *versus* fusion point. A question of nomenclature. F. A. HARVEY. *Proc. A.S.T.M.*, **34** [Part I], 376–77 (1934).—The terms "fusion point" and "melting point" or "softening point" have frequently been used in refractory terminology to describe the property which is defined as pyrometric cone equivalent in the A.S.T.M. standard definitions of terms relating to refractories. The term "fusion point" was almost universally used in refractories standards before the adoption of pyrometric cone equivalent. Since common refractories have neither a melting nor a fusion point, as these terms are understood by the old established sciences, it appears illogical to use either of these terms in a new sense in the field of ceramics. R.A.H.

Statistics for the ceramic industry. THOMAS N. KURTZ. *Bull. Amer. Ceram. Soc.*, **14** [2], 80 (1935).

BOOKS

A.S.T.M. Tentative Standards, 1934. ANON. Published by Amer. Soc. Testing Materials, Philadelphia, Pa. 1257 pp. This annual volume contains all of the A.S.T.M. tentative specifications, methods of test, and definitions of terms covering engineering materials and the allied testing field. This book contains 236 tentative standards, of which 48 are included for the first time. Over 60 others were revised and are given in their latest form. R.A.H.

Index of All-Union Standards Arranged by Numbers, Alphabetically, and by Branches of Public Economy. A. V. SMETANIN. State Pub. House of Standardization and Rationalization, Moscow-Leningrad, 1934. 792 pp. Price 12 R. This book, which reflects the widespread standardization movement in the U.S.S.R., is the first attempt to make a complete index of all standards approved by the All-Union Standards Committee (V.K.S.) under the Council of Labor and Defence and the Standardization Committees under the People's Commissariats (K.S./N.K.). The book consists of four parts as follows: Part I, a numerically arranged index of the 6719 standards approved by the V.K.S. and the K.S./N.K.; Part II, a numerical list of the standards approved by the Standardization Committees of the People's Commissariats; Part III, a subject index alphabetically arranged of standards approved by the V.K.S. and the K.S./N.K.; and Part IV, a classified list of the standards arranged under the separate branches of public economy. The Index embraces all existing standards in the fields of metallurgy (ferrous and nonferrous), mining and fuel industry, machine construction, metal construction and articles, electrotechnique, chemical, textile, and leather industries, wood (timber) and woodworking industry, paper and printing, glass, porcelain, and faience, building industry, transportation, agriculture and food products, metrology, scientific-technical symbols and terms, and a group of general standards. For those interested in the standardization activities in the U.S.S.R. this book is of great value.

S.I.PERKAL

Index to A.S.T.M. Standards and Tentative Standards. ANON. Published by Amer. Soc. Testing Materials, Philadelphia, Pa., 1935. 142 pp. The 491 A.S.T.M. standards and 241 tentative standards in effect as of Jan. 1, 1935, have been indexed under appropriate key words.

R.A.H.

Transactions of the First International Congress on Glass and Ceramics (Atti del 1º Congresso Internazionale del Vetro e della Ceramica). Federazione Nazionale Fascista dell' Industria del Vetro and Federazione Nazionale Fascista dell' Industria della Ceramica e Affini, Milan, Italy, 1934. 680 pp. Price 50 lira. Seventy-two papers from the First International Congress on Glass and Ceramics held in Milan, Italy, September 16 to 25, 1933, are mentioned. Those papers devoted to the problem of international standardization, in the broad sense of the word, are of special interest. Not all the papers were read at the Congress and not all have been reproduced in full in this volume. The publication of papers in the different languages of the nations represented at the Congress (English, French, German, Italian) has led to some misprints. Nevertheless the volume represents the first publication devoted to international coöperative work in the fields of glass and ceramics, and is of scientific, technological, and historic value. S.I.PERKAL

Treatise on Ceramics (Traité de céramique). B. GREBER. Encyclopedie Roret Soc. française d'éditions litteraires et technique, Vol. I. 642 pp. Price 45 F. Foreign postage 9 F. Reviewed in *Rev. mat. constr. trav. pub.*, No. 301, pp. 187–88*B* (1934).—The first part of this work which forms part of the New Roret Encyclopedia is a study of the different stages of manufacture. The second part deals with ceramic products. M.V.C.

PATENT

Treatment of green clay, shale, etc., brick before firing. H. H. BAILEY AND J. F. GILL. Brit. 422,269, Jan. 23, 1935.